THE ENGINEER

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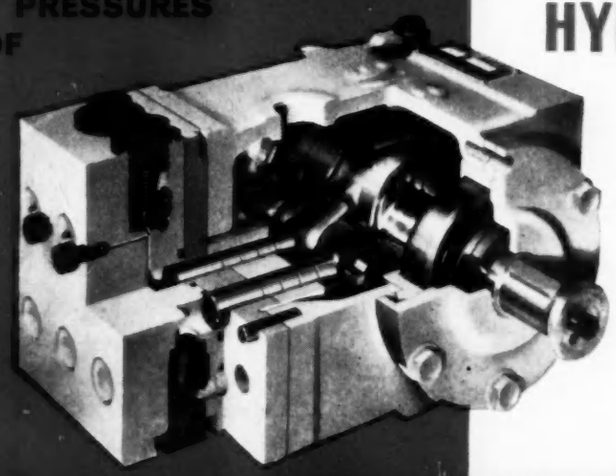

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		1000 r.p.m.	1500 r.p.m.	max. pr. p.s.i.	Input H.P.	Max. pr. p.s.i.	Input H.P.	Max. pr. p.s.i.	Input H.P	lb.
GVS		0.28	.43	5700	2	6500	2.5	7100	3	62
GV6	12.12	0.8	1.21	6000	6	6750	7.5	7100	8	62
	14.12	1.1	1.65	4600		5400		6000		62
	16.12	1.47	2.2	3600		4300		5000		62
GV15	16.15	1.87	2.76	5700	12	6500	15	7100	17	86
	18.15	2.32	3.53	4600		5460		6000		86
	20.15	2.97	4.4	3600		4390		5000		86
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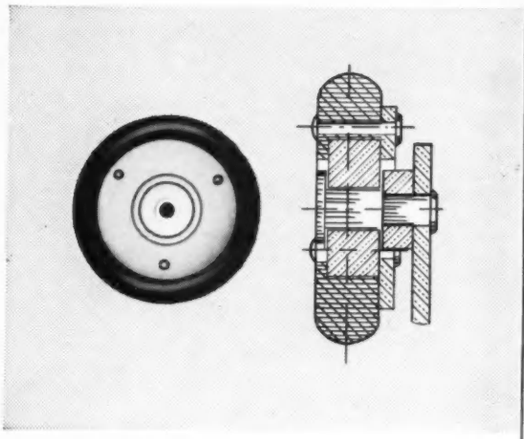

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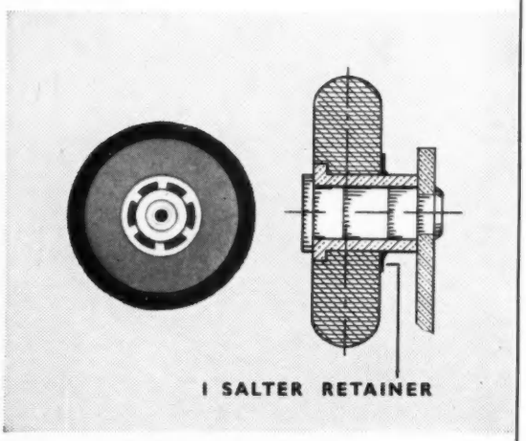

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THE ENGINEER

Established 1856

No. 5511 **SEPTEMBER 8, 1961** VOL. 212

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SUBSCRIPTIONS U.K. and ABROAD £5 10. 0. p.a., including postage (CANADA £5 5. 0.). Single copies 2s. each, plus 9d. postage. Also on sale at newsagents.

'THE ENGINEER' BUYERS GUIDE Published annually. One FREE copy is sent to all direct postal subscribers on publication and delivered by newsagents to all regular readers. Additional copies are obtainable at 10s. 0d. each. Postage 2s. 0d. extra.

Published every Friday by
MORGAN BROTHERS (PUBLISHERS) LTD., AT 28, ESSEX STREET, STRAND, LONDON, W.C.2. Telephone : CENtral 6565

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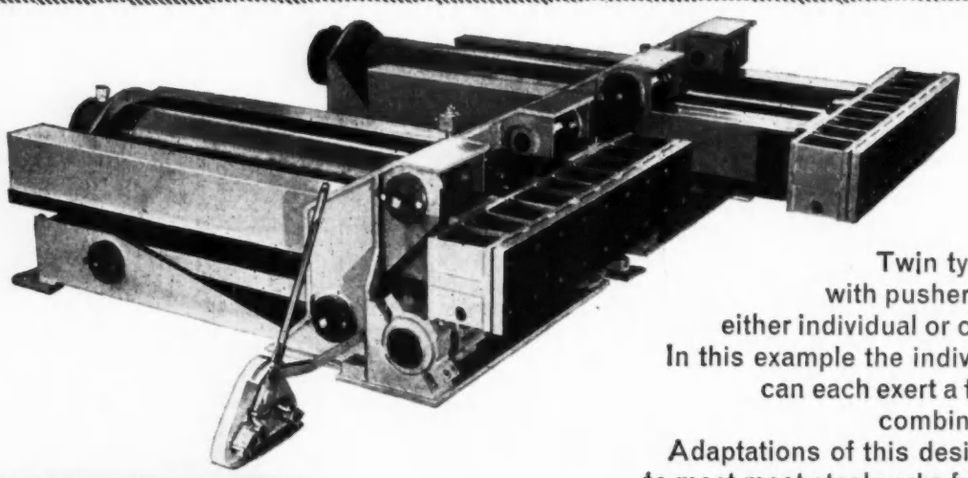

Twin type furnace pushers with pusher heads arranged for either individual or combined operation. In this example the individual pusher heads can each exert a force of 35 tons or a combined force of 65 tons. Adaptations of this design can be supplied to meet most steelworks furnace applications.

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THE ENGINEER

No. 5511 SEPTEMBER 8, 1961 Vol. 212

MAN AND THE ATOM

A generation ago anyone who hinted at the possibility of the continued existence of evolution amongst human beings would have been laughed to scorn by scientists and humanitarians alike. For there is no evidence of any physical change in man's make-up over the last several thousands of years and plenty of evidence in historical writings that men of some thousands of years ago behaved very much like those of to-day. Yet it may well be, all the same, that man is still evolving. In his presidential address to the British Association for the Advancement of Science, delivered on Wednesday of last week, Sir Wilfred Le Gros Clark discussed the development of the human brain. In particular he drew attention to "the enhancement of the interconnections between the basal brain and the cortical brain, to the extent that emotional drives may be made much more subservient to the ideational processes which are based on cortical activity. The latter can now, if needs be, hold these drives in check, or exploit them by directing them into channels serving the co-operative requirements of human society. Of course, many of us do not use this machinery of the brain as efficiently as we might do; but the point is that, in neurological terms, the machinery does exist to be made use of." It must have occurred to many of his hearers that there may be evidence in history for a growing use by human beings of this machinery. Certainly the further back one delves into history the less easily do men seem to have co-operated freely; regimentation or subjection were necessary to hold numbers of them together for the performance of any large co-operative task. By contrast the picture to-day, at least amongst the more civilised nations of the West, is of individuals easily co-operating for all kinds of activities, almost all of which are now regulated by committees. And the outstanding point about the work of a committee, of course, is that it can do little useful work unless the individuals concerned actively desire to sink individual differences and co-operate.

But what, it may well be asked, has all this to do with engineering. It probably has a lot to do with it! For if this kind of evolution of the human mind really is taking place (for our part we think it probably is), engineers are largely responsible for making it necessary. The invention of railways, improvements to ships and to communications generally, not to mention the world-wide trade which has been created by the development of new techniques, especially engineering ones, have made it essential that man's existing but hitherto little used co-operative potentialities should be rapidly developed. Mankind has responded. "Undoubtedly one of the most important developments in science in recent years is the multiplication of international congresses . . . Even more significant . . . is an evident tendency to replace the term international by more comprehensive and all-embracing titles. Thus we have the Food and Agricultural Organisation, the World Meteorological Association. . . ." When historians look back on the twentieth century it well may be that, despite the turmoil of wars and revolutions, they will see in it predominantly an almost explosive development of man's ability to co-operate. They will see the human mind evolving to meet the challenge of surroundings changed and so rapidly changed by the ability of engineers to apply scientific discoveries that only a species as adaptable as *homo sapiens* could possibly have met the challenge without disaster.

But — alas! — it is far from certain that evolution is taking place fast enough. At the very moment when Sir Wilfrid was delivering his address and saying "an essential prerequisite for any attempt at further unification for the good of mankind as a whole is the ability to give full expression to the impulse for co-operation which is so characteristic a feature of the humanity of man," the Russians were announcing the intention to resume the testing of nuclear weapons, an intention put into effect a day or two later. Scientists invented and engineers have developed nuclear weapons of such destructive power that widespread use of them could conceivably wipe out the human race and would certainly face it with a biologically hostile radioactive environment in which it might prove unable to survive. Thus the very existence of such weapons emphasises the need to develop world co-operation. But, instead, the nations of the world are being brought down to the childishness of shouting at each other "Yah! Boo! I'm stronger than you!" If man is to develop his "bump" of co-operation fast enough to survive the challenge of his nuclear knowledge Sir Wilfrid's closing words can be aptly quoted; "time is getting very short."

ROAD RESEARCH

Annual reports, even of research bodies, often make very dull reading for all but people actively engaged in one way or another in the fields concerned. But the Road Research Laboratory has the advantage in that respect that everyone uses the roads and a high proportion actually drive upon them. The consequence is that almost everyone with some appreciation of research methods can find something of interest in the report "Road Research 1960" which was published recently. A civil engineer will, of course, turn first to that section of the report which covers materials and methods of construction. In this field in the years since it first started work the Laboratory has made some very substantial contributions to knowledge. Yet it still remains true that the research worker must be patient. Because there is so much road building going on, here and else-

where in the world, it is very desirable that there should be a scientific method of deciding upon the economic thickness of base material and surfacing material for any given set of traffic and subgrade conditions. But, unfortunately, there is no quick and satisfactory alternative to full-scale road experiments. Only now, for example, are the results of the full-scale experiment at Alconbury Hill beginning to prove really valuable; and before the full value will become apparent of an experimental prestressed concrete road some 2 miles long built in Belgium by the Belgian Centre de Recherches Routieres with which the Road Research Laboratory is collaborating, some years, no doubt, will have to pass.

So much valuable work has been done by the Laboratory to make roads and vehicles safer that all road users should be thankful the Laboratory exists. They should also be somewhat resentful when, as still happens occasionally, a Minister fails to make use of the Laboratory's work or adopts policies without consulting it. The special value of the Laboratory lies in its scientific detachment. It is not interested in what people ought to do and it draws no moral strictures on human behaviour. It is interested in what people do do; and having discovered how people do, in fact, behave it suggests ways in which roads can be designed, laid out and constructed to allow for this kind of behaviour.

Much of the work of the Laboratory on traffic engineering is statistical. A diagram in this section strikes us as particularly informative for those whose job it is to design new roads or widen old ones. How much traffic should they be designed to carry? The Laboratory has recently compared the rates of growth in the number of vehicles in use in different areas. Not surprisingly it has been found that in areas having the higher numbers of vehicles in use, relative to the population, the growth rate is slower. The relationship is such that a "saturation" level for vehicles per head can be estimated at which no further increase in the number of vehicles in use would occur except, of course, through an increase in the population. In the United States saturation level, so estimated, has lain around 0·7 vehicles per head ever since 1929. For this country it has risen from 0·25 in 1935 to 0·6 now and it appears to be still rising, although the actual existing number of vehicles in use is still only about 0·2 per head of the population. It thus becomes possible to predict with some certainty that by the end of this century there will be about three times as many vehicles per head as there are now and presumably about three times as much traffic on the roads. Thereafter there is likely to be very little further increase. Even by the mid-eighties, judging by the present rate of increase, a figure of 0·5 vehicles per head will have been reached and the rate of increase should be tailing off. That is a time so relatively soon that all new motorways should obviously be now designed to carry the amount of traffic they will have to carry when the saturation level is reached. Are they being so designed? Will the traffic carrying capacity of such two lane duel carriageway motorways as the Preston by-pass, the Ross Spur, and the Doncaster by-pass prove sufficient; or are those roads due, within twenty years or so, to become dangerously congested like so many of the highways built in the thirties? Lack of foresight was excusable in the thirties; saturation level in terms of vehicles per head being predictable it is by no means so excusable now.

WORLD REGISTER OF PRODUCTION ENGINEERING RESEARCH

As in many other branches of industry there is much duplication of research in production engineering throughout the world. With this in mind the Production Engineering Research Association in 1960 made a study of the need which seemed to exist for a world register of production engineering research to assist in keeping all engaged in this class of work fully informed about investigations being carried out by research organisations, firms, universities and colleges in all parts of the world. Proposals, based upon this study, were presented to the General Assembly of the International Institution for Production Engineering Research, which agreed to the compilation of such a register, and this work is now to be carried out by P.E.R.A., financial support having been granted for two years by O.E.E.C. The register will cover all production research carried out in the years 1959-62 and will summarise plans for research for the following three years. The register will give as much information as can be obtained about establishments carrying out programmes of research relevant to production engineering, including details of the researches undertaken, the staff, workshops, laboratories, special facilities and equipment. Information will be sought through a questionnaire which is now being sent to research establishments, and P.E.R.A. has invited all organisations carrying out any form of production research to apply for the questionnaire.

The hope, of course, is that the publication of such a world register in various languages will reduce the risk of investigations being duplicated in different parts of the world, and that by overcoming language barriers, the register will facilitate continuous contact and communication between scientists and engineers concerned with production. It is, we suppose, unlikely that the register will be at all nearly complete. For many establishments, industrial and otherwise, put a close seal on their research activities — particularly if they are likely to give a line on future development trends to competitors. This may not apply so much to fundamental research as to applied development, but it is a fact which must be taken into consideration. Furthermore, unless such a register is well used it may tend to concentrate study of particular problems in so few establishments that there will be too few and insufficiently varied approaches to possible solutions. There is virtue as well as vice in duplication! But there can be no doubt of the value of the information in such a register to research workers and it should facilitate closer co-operation amongst them.

A SENSIBLE SOLUTION

When President Kennedy's administration announced its intention to retain effective nuclear striking power in the N.A.T.O. area for American and Allied use, it was suggested in these columns that the United States offer to commit five "Polaris"-carrying nuclear submarines to N.A.T.O. provided the basis for a solution of Britain's post-1970 defence problem. The two nations are at present responsible for providing the N.A.T.O. deterrent against an all-out mass destruction war. And if the manufacture or possession of thermo-nuclear weapons by a number of other countries is to be avoided, or at any rate discouraged, it would be very desirable for the United States and Britain to retain this respon-

sibility. Indeed the objection which the Parliamentary Opposition put forward to this country having deterrent capability arises in the main from the need to discourage by example the widespread possession of these weapons. Britain's difficulty in contributing to the deterrent is however mainly financial. With her world-wide commitments it is essential that she should maintain the necessary conventional forces to ensure that some local trouble or dispute overseas is dealt with before it becomes of vital interest to a major power. Fortunately, the V-bomber forces, intended after the war to be armed with either conventional or nuclear bombs, are also able to launch the short range stand-off bomb "Blue Steel" and the 1000-mile ballistic rocket "Skybolt," both of which can be fitted with a thermo-nuclear warhead. Britain is thus managing in the meantime to provide a substantial contribution to the deterrent while maintaining and even strengthening her conventional armed forces. But it is now generally realised that improvements in anti-aircraft measures will necessitate these bombers being replaced or at least supplemented from 1970 onwards by a seaborne deterrent. Though it would be possible to build large ships of cruiser type to carry "Polaris" missiles in addition to guns, the Admiralty is satisfied that, under present-day conditions, the safeguarding of the sea communications against surface ship attack can be adequately assured by the aircraft carrier operating with the new type of large destroyer now building, armed with 4·5in guns and anti-aircraft guided missiles. It would thus seem a waste of money to build ships larger and with a more powerful gun armament than necessary to safeguard the sea routes — ships whose deterrent value is obviously far behind that of submarines which can fire sixteen "Polaris" missiles when submerged. But "Polaris"-carrying submarines are useful for little else than to act as a deterrent and each one of the present vintage is costing the Americans over £40,000,000 to build. The later classes — commencing with the "Ethan Allen" of 5900 tons — will be much larger and more costly, launching "Polaris" missiles with a range of 1500 miles, soon to be increased to 2500 miles. Britain just cannot afford these huge sums to provide deterrent bases.

America's problem is not one of finance. Feeling that she is chiefly responsible for preventing a thermo-nuclear war, the United States attaches particular importance to maintaining a "strike-back" capability, which requires different types of deterrents adequately protected from unexpected attack. Though she is now placing more and more reliance on the "Polaris" submarine for this purpose, she also continues to pin her faith on the B-52 and B-58 bombers and the liquid fuel "Atlas" and "Titan" and solid propellant "Minuteman" ballistic rockets, which all have intercontinental range; she has, too, a number of medium range bomber and ballistic rocket bases in various other N.A.T.O. countries. Happily she has the financial and material resources to do so in addition to maintaining very large conventional forces. But the United States is faced with a serious manpower problem. The bulk of her manpower for the Armed Forces is provided by short-service men who, after attaining a certain amount of technical skill, leave the Service, attracted by the higher wages offered by civilian firms. Not only "Polaris" missiles, but all the new and complicated anti-submarine warfare and other weapons and weapon systems now used in warships require men to have a technical training roughly equivalent to that of a graduate electrical engineer. The United States Navy is finding increasing difficulty in providing the highly skilled personnel required. It is interesting to note in this connection that whereas in 1935 there were only seven technical rating branches (including telegraphists) in the Royal Navy, there are now no fewer than twenty-nine. But the Royal Navy is nowadays well supplied with skilled ratings. After an initial period of twelve years' service, two out of every three men are re-engaging for a further period of nine years to complete time for pension. It is thus very satisfactory that the proposal—originally put forward in these columns — that Britain should help the United States to overcome her chief difficulty by offering to man and operate some of her "Polaris" submarines on behalf of N.A.T.O., is now being supported in Parliament and in the British press. All that is needed is closer co-operation with the United States Navy. The personnel strength of the Royal Navy has already been reduced to 100,000. By increasing its planned peacetime strength from 90,000 to 95,000 men, the Royal Navy could both man fifteen "Polaris" submarines and use the consequent saving on V-bombers to increase the conventional forces and weapons required for the most likely conflicts Britain will be faced with in the future.

The Engineer—100 Years Ago (SEPTEMBER 8, 1861)

"AN AGGRIEVED AUTHOR"

"(*To the Editor of* THE ENGINEER).

Important Invention — Steam Boiler Explosions Rendered Impossible; by J. Hopkinson and Co., Patentees of the Compound Safety-Valve, &c.&c.&c. — Britannia Works, Huddersfield, August 29th, 1861.

Sir,—I learn by this morning's post (through my friend Mr. Burton), who has made application for the MS. I forwarded to you, as a reply to your review of my treatise, the 'Steam Engine Explained,' that you refuse to give it up. I beg to say that the papers in question are my property '*not yours*,' therefore I request that you will return them at once, either direct to me or to Messrs. Burton and Co., 2, Whitefriars Street, Fleet Street, London. I may remark that your conduct is anything but pertaining to a man or gentleman.

You publish a scurrilous article, which you call a review of my book — the third edition — from which it is quite evident that the subject is one with which you are altogether at sea, and undoubtedly has a less knowledge than most operative engineers.

Your cowardly conduct in this matter, refusing me a reply, and then withholding my property, deserves the highest censure, nay, more, such a chastisement as I shall take the liberty of giving you for your cowardice, viz., a horse-whipping.

Men like you, who make the press a vehicle of injury and oppression, are a disgrace to the profession.

I am, Sir,
Yours truly,
J. Hopkinson.

From the tone of the above pleasant communication, our readers may be able to estimate the character of the one we withheld. Mr. Hopkinson, who has neglected to say when we may expect him up to London, appears to have fallen a victim to over pressure, from neglecting, perhaps, to wear one of his own safety valves.—Ed.E."

Molybdenum Disulphide Dry Film Bonded Coatings

By H. J. WINCH, M.I.Nuc.E., Comp.R.Ae.S.* and L. A. HICKS, A.M.I.Nuc.E.*

During the past few years the use of molybdenum disulphide dry film bonded coatings has become of increasing importance in metal working, nuclear engineering, aircraft engineering, missile development and the processing industries. It has long been known that molybdenum disulphide can be used effectively as a lubricant in conditions where bearing pressures and temperatures are beyond the capacity of conventional or synthetic oils and greases, the use of which under such conditions would almost certainly permit seizure, pick-up, galling, &c., to occur. Dry film bonded coatings offer additional advantages in certain fields of activity since they can, as the name indicates, provide protection in the completely dry state and are resistant to adverse environmental conditions.

THE value of molybdenum disulphide for certain lubrication problems to be found in most fields of engineering activity is now well established.

The technology of molybdenum disulphide solid lubricating materials is an extensive and complicated one, and can be divided into a number of fairly clearly defined sections. One of the sections is concerned with the application of molybdenum disulphide dry coatings, generally called dry film bonded coatings, by which dry lubrication is achieved. Dry film bonded coatings can be used in many cases where conventional mineral or synthetic oils or greases are prohibited on account of chemical decomposition or unwanted product or plant contamination.

To those not familiar with molybdenum disulphide it may be appropriate to mention briefly some points concerning this solid lubricant.

Molybdenum disulphide is normally found naturally in "altered granite" in thin vein formations (Fig. 1).

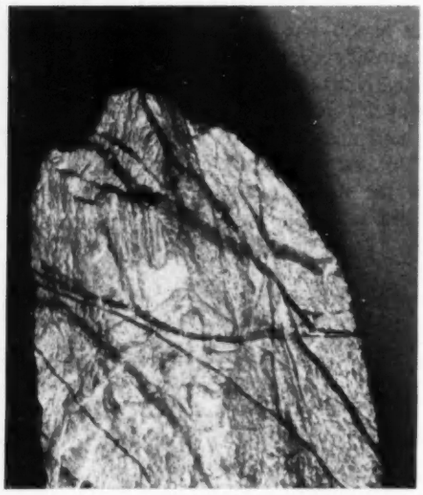


Fig. 1—Piece of "Altered Granite." The seams of "Molybdenite" are clearly visible

The average molybdenum disulphide content of the rock as at present being mined is approximately ½ per cent. It is essential to remove all impurities from molybdenum disulphide which is destined for lubrication purposes. A purity in excess of 98·5 per cent is now the rule rather than the exception.

Molybdenum disulphide is chemically very stable; it is insoluble in water, oil and alkalies and is unaffected by most acids except strong oxidising agents such as *aqua-regia* and hot concentrated hydrochloric and nitric acids (see properties, Table I).

* Engineering Department, K. S. Paul (Molybdenum Disulphide), Ltd., Nobel Road, London, N.18.

TABLE I—*Properties of Molybdenum Disulphide*

Colour	Grey
Specific weight	4·9
Molecular weight	160·08
Hardness	1 to 1·5 (Mohs scale)
Melting point	Above 2200 deg. Fah.
Thermal stability	In air: from −300 deg. Fah. to +800 deg. Fah. In vacuum and inert gases: up to 2100 deg. Fah.
Bearing capacity	Over 400,000 lb per square inch.
Coefficient of friction	0·05 to 0·09 (in powder form)
Chemical stability	Resists attacks of most acids Attacked by *aqua regia* and boiling hydrochloric acid (HCl), hot concentrated sulphuric acid (H_2SO_4) and hot nitric acid (HNO_3) Decomposed by fluorine and chlorine but not by dry H.F.
Magnetic properties	Diamagnetic

The flake-like laminar structure (Figs. 2 & 3) of molybdenum disulphide contributes to its lubricating properties. Each molecular lamination is composed of two outer layers of sulphur atoms between which is "sandwiched" a layer of molybdenum atoms. Within each layer the atoms are arranged in hexagonal formation.

The bonds between the molybdenum and sulphur atoms in one lamination are stronger than the bonds of the sulphur atoms on the surface of one lamination with those on the surface of an adjacent lamination.

As a result of these weak sulphur–sulphur bonds of adjacent laminae, no great shear force is required to slide one layer over another. It will be seen from this brief description that molybdenum disulphide particles possess precisely those characteristics required of a high duty lubricating material, i.e. immense resistance to penetration in the direction normal to relative surface movement, and easy shear in the direction parallel to the surface movement.

The estimated molecular thickness of molybdenum disulphide laminæ is 1/40,000,000in. There exist therefore, in a molybdenum disulphide film of 1/1000in thickness, 40,000 cleavage or shearing planes.

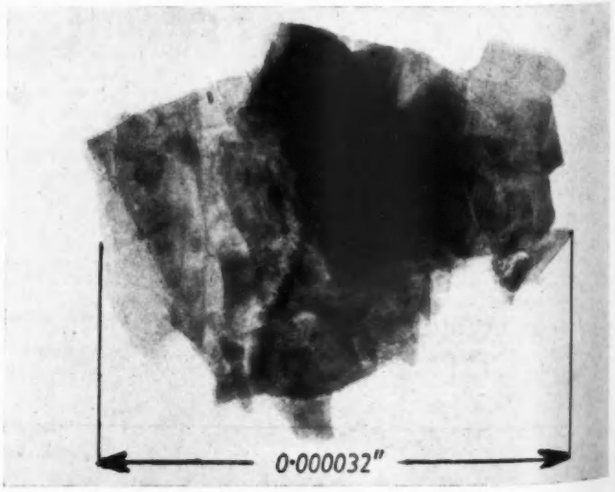


Fig. 2—Electron photomicrograph of a single MoS_2 particle (magnification ×94,500). The actual crystal is 0·000032in long and the irregular-shaped laminae can be clearly distinguished

Molybdenum disulphide possesses another excellent property, i.e. its great affinity to certain metals;—once having been "filmed" on to a metal surface, it can provide an effective load-bearing layer estimated to withstand unit loads in the region of 400,000 lb to 500,000 lb per square inch (possibly more).

The laminar theory does not, however, explain entirely the lubricating ability of molybdenum disulphide, and more recent trends of thought on the subject embrace the possibility of a measure of surface adsorption and also do not rule out some chemical action under the influence of catalytic action of the molybdenum.

Laboratory tests have produced molybdenum disulphide dry film bonded coatings which have withstood, for limited runs, specific bearing pressures of 180,000 lb to 210,000 lb per square inch without observable increase in temperature, noise or torque resistance and which left the two bearing surfaces unmarked, except for a high polish.

A number of dry film bonded coatings is shown in Table II. The formulations differ primarily in the "binder" or bonding agent required to fix the coating of molybdenum disulphide to the metal bearing surface. As a result of this variation in the "binder" or bonding agent different methods of application of the dry film coating are necessary Bonded coatings may be brushed, sprayed, or dip applied to the component after pretreatment. The subsequent curing temperature, if any, will be determined by the curing characteristics of the "binder" or bonding agent.

In practice it is often found convenient to warm the parts to which the dry film bonded coating is being applied to a temperature of about 160 deg. to 212 deg. Fah., depending on the mass of the part and environmental conditions of the work, the number of parts being dealt with, and also the local organisation of the job (large or small numbers being handled).

Normally dry film bonded coatings have a thickness of between 0·0001in–0·0005in. but again experience may indicate that a thickness outside this range is desirable. Generally it will be found that only that amount of molybdenum disulphide in fairly intimate contact to the metal surface actually performs a useful purpose and therefore in many cases there is little point in applying a relatively thick film.

A film thickness of a few tenths of a thousandth of an inch can be applied in applications where this is desirable, for example, where parts fit inside others and where force-fits are inevitable.

For high temperature operation suitable "binders" are available for temperatures up to a little over 570 deg. Fah. For operation at lower temperatures than this appropriate bonding agents may be used to suit other working conditions. Most of the available bonding agents begin to decompose at temperatures above 570 deg. Fah. and it will be generally found when this takes place that even though the "binder" may deteriorate the molybdenum disulphide has formed a tightly attached film on the metal surface. Heat assists the natural tendency of the molybdenum disulphide to adhere to metals, as also does the mechanical working. When correctly cured, dry film bonded coatings are not adversely affected by low temperatures, and therefore such coatings may be used at well below the temperatures in which any conventional mineral or synthetic oils or greases are able to operate.

Another type of application for molybdenum disulphide dry film bonded coatings is as a protective underlay for the initial running-in of oil or grease lubricated bearings where severe operating conditions are anticipated. During experimental tests a dry film bonded coating was applied to the main and big end bearing shells of a diesel engine of approximately 160 h.p. in which the lubricating system gave some cause for concern. Subsequently, after running the engine for four hours at above maximum permissible revolutions per minute, the engine was dismantled for bearing inspection and the total bearing area still having the dry film bonded coating intact was of the order of 95 per cent. Where the film had been ruptured it was evident that hard foreign bodies or particles had become introduced into the bearing clearance by the pressure oil supply.

Some of the advantages which result from the use of molybdenum disulphide dry film bonded coatings can be found in industries where applications exist in which no greases or oils are desirable after the machine or apparatus has been assembled. A few are mentioned below :

(*a*) No contamination of foodstuffs where machinery is being used during manufacturing processes.

(*b*) During the passage of components through stoving ovens, &c., in which case the finished product would be blemished by droplets of oil or grease falling from parts of the production machinery such as conveyor rollers, links, chains, and bearings on account of the inability of conventional lubricants to withstand high temperatures without melting or dropping off.

(*c*) In atmospheres where abrasive dust particles are present and where oils or greases would rapidly collect quantities of destructive material.

(*d*) Where mechanical parts are called upon to operate in water or in some other conditions of non-lubrication or inferior lubricating conditions.

(*e*) In nuclear engineering applications where conventional oil or grease-like compounds deteriorate rapidly in use.†

This is important for nuclear engineering in which a number of difficulties have been experienced when using conventional mineral and synthetic oils and greases due to some of these materials breaking down under the influence of irradiation. Additionally much of the mechanical equipment associated with nuclear reactors may be called upon to operate at elevated temperatures, it has further been noted that numerous mechanical parts are fabricated from grades of stainless steel particularly susceptible to pick-up and seizure when operated in the dry condition.

† The latest information to hand indicates that molybdenum disulphide survives, without impairment of its lubricating abilities, when irradiated to 1,000,000,000 rads.

Some stainless steels are difficult to lubricate other than under purely hydro-dynamic conditions. In the absence of these conditions the operation of mechanical parts in intimate moving contact with each other becomes practically impossible, or the parts are subject to very rapid rates of wear.

One interesting application in this field of work concerned a machine designed for the remote cutting to length of reactor fuel rods, the machine being located behind a great thickness of concrete. This machine was built almost entirely of 18/8 stainless steel. A substantial stainless steel drive shaft for the cutting head was designed to turn at approximately 2000 r.p.m. in porous bronze bearings impregnated with mineral oil. There were four main bearings of porous bronze, the two centre bearings forming part of a moving cutting head. The two journals comprised the full diameter of the shaft. The two remaining journals at the ends of this driving shaft were formed by the shaft turned down to approximately 1in diameter. The relative surface velocities in the bearing were approximately 1300ft per minute in the big bearing and approximately 500ft per minute in the small bearings. In addition to transmitting torque for the circular cutter, the shaft in this vicinity also carried the full weight of the cutting head. During initial running, trouble occurred in all the bearings, which became very hot. Seizure was persistent in the two large centre bearings after brief runs, in spite of additional extreme pressure grease being added to the bearings. No run longer than about fifteen minutes was achieved : in some cases only a minute or two of running time was completed before total seizure occurred. After investigation it was agreed that a first-aid treatment should be attempted. In order to ascertain the bearing's behaviour using molybdenum disulphide as a lubricant, and after cleaning the shaft journals and bearing shells, some molybdenum disulphide of suitable grade was vigorously applied to all affected areas. This was regarded as a very thin dry film bonded coating. Some molybdenum disulphide was then added in suitable proportions to the existing E.P. grease and the machine re-assembled.

On starting up it was found that the bearings became quite warm (although not too hot to touch), there was no evidence of seizure. During this test run the machine continued to operate for a period of about two hours without the previous troubles re-occurring. It was stated that the ammeter reading of the driving motor (1·8A during this run) was the lowest recorded during any runs of this machine.

It was the author's intention to recommend a dry film bonded coating for these bearings had any further trouble been experienced, but in the event, such treatment was obviously not essential.

Applicational Methods and Procedures

Over a long period of investigation into the most convenient and effective method of applying molybdenum disulphide dry film bonded coatings to metal bearing surfaces, a procedure has been developed which with small variations (determined by the bearing materials and types of bonding agents used) has become more or less standardised for this type of work. The preliminary stages follow very closely the procedures generally adopted for the successful application of other forms of metal protective treatments. As with these, proper preparation of the surfaces is essential.

It has been found for example during laboratory investigations and tests that

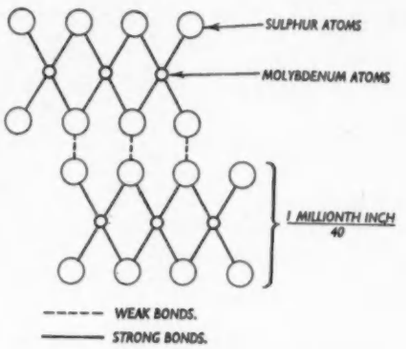


Fig. 3—Diagram illustrating the structure of MoS_2

appropriate pretreatments of metal surfaces cannot only facilitate the application of the dry film bonded coatings, but additionally such pretreatments immensely enhance the effective endurance life of the lubricating films. Fig.4 illustrates some results obtained during extensive tests of dry film bonded coatings applied to hard steel bearing surfaces with and without appropriate metal surface pretreatment. It will be seen that dry film bonded coatings applied to the pretreated surfaces had much longer endurance lives than those applied to untreated metal surfaces. (In each case the test result is the means of four runs.)

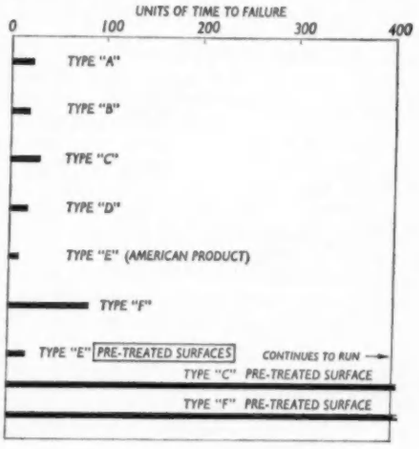


Fig. 4—Effect of pretreatment

Correct heat-treatment during processing also results in a marked improvement in the endurance lives of these lubricating films. Fig. 5 illustrates the comparison of the endurance lives of a selection of dry film bonded coatings applied to unpretreated metal surfaces. In the one case the films were applied to the parts at room temperature (70 deg. Fah.) and subsequently allowed to air dry and cure under these conditions.

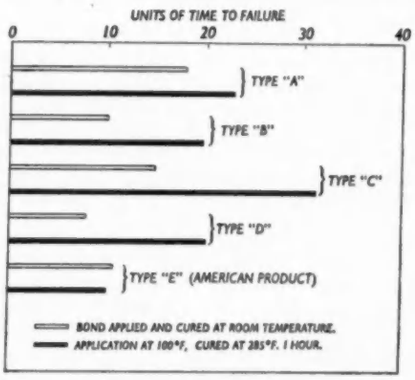


Fig. 5—Effect of heating

TABLE II—*Some Bonding Agents and Typical Curing Times*

Bonding agent	Temperature of heat cure, deg. Fah.	Curing time	Air cure, room temperature
Nitrocellulose xylole	400–475	One to two hours	No
Epoxy phenolic	300–450	Fifteen to sixty minutes	No
Vinyl butyral	360–400	Thirty minutes	Yes, but heat preferred. Twenty-four to forty-eight hours
	On non-metallic materials, according to the material	Thirty minutes	
Vinyl butyral with composite modifier	350	Eight minutes	No
	435	Twenty minutes	
	600	Five minutes	
P.T.F.E.	680	Ten to fifteen minutes	No
Aerosol spray (" Moly-Vapour-Bond ")	Up to 400	Thirty minutes	Yes, but heat preferred. Twenty-four to forty-eight hours
" Self-Etching " Bonding Agent	Up to 450	Not critical—use visual inspection to check	Yes, but heat preferred

The longer columns represent the endurance life of the same coatings applied to the unpretreated bearing surfaces at 100 deg. Fah. and subsequently baked at a temperature appropriate to the particular bonding media.

From the above it will be seen that the initial stages of a dry film bonded coating applicational technique are as follows :

(1) *Thorough Cleansing of the Metal Surfaces.*—All surface contaminants such as oil, grease, paint and oxide scale must be removed. It is advisable in some cases to use mechanical cleansing methods in cases of severe contamination. Thereafter vapour degreasing by trichloroethylene is normally satisfactory. Failing this, solvent cleansing using liquid trichloroethylene or carbon tetrachloride, or washing with benzene, alcohol, acetone or petroleum ether may be satisfactory.

(2) *Pretreatment of Metal Surfaces.*—Pretreatments may be of mechanical or chemical nature. If mechanical pretreatments are decided upon, the aim should be to produce a surface finish of about 30 to 50 micro-inches (C.L.A. or R.M.S.). From this it will be seen that for the application of molybdenum disulphide dry film bonded coatings the finest metal finishes are not only unnecessary but are in fact undesirable. In one case, the authors were confronted with the necessity of applying dry film bonded coatings to some very large steel hinge pins of strip coilers the seizure of which prevented the collapsing of the mandrill. As no facilities could be found for chemical or conventional mechanical pretreatments a home-made sand spraying unit was devised from oddments in the maintenance workshop. Sand was sprayed violently at the bearing surfaces of the pins. After bonding and re-assembly in the machine no further trouble was experienced.

Mechanical pretreatments could normally consist of fine abrasive blast or vapour blasting, i.e. abrasive in liquid. In emergencies vigorous rubbing in all directions with a medium abrasive cloth or paper may be used. After mechanical pretreatments a second stage of cleansing is desirable to remove any adhering hard abrasive particles.

For carbon steels or cast iron chemical pretreatments may consist of iron or zinc manganese phosphate coating, followed by hot rinsing. For the so-called " stainless steels " phosphating may not be satisfactory, but suitable methods of etching the surfaces have been developed. In no case to date has it been found impossible to produce a satisfactory surface on any stainless material offered for the application of dry film bonded coatings.

Aluminium and aluminium alloys may be pretreated by sulphuric acid, chromic acid, or the new " hard " anodised process.

Suitable pretreatments are available for other non-ferrous bearing surfaces such as copper and its alloys, magnesium alloy and plated components, if desired.

Whilst molybdenum disulphide dry film bonded coatings may be applied to non-ferrous materials such as rubber, and plastics, it is more usual to embody a suitable quantity of molybdenum disulphide in the formulation of these materials.

(3) *The Bonding Process.*—Having thus completed the preliminaries to the application of the dry film bonded coatings it is recommended that wherever practicable, the parts should not be further handled, except by the use of clean dry tongs.

If it is decided to brush coat the bonded film it will be found highly desirable to first warm the parts to about 170 deg. Fah. (preheating time depending on the mass of the material). The liquid bonding suspension should be kept thoroughly agitated by means of a mechanical stirring device. This is desirable because of the high specific gravity of molybdenum disulphide in a volatile solvent. Even the presence of the bonding agent in the solution may not always prevent the particles sinking to the bottom of the container, particularly as the most effective particle size in use is greater than the maximum size that could be permanently suspended.

If it is decided to use the brush method to apply the coating a suitable type of brush is one which has fairly soft bristle. The liquid coating should dry fairly slowly, and not form bubbles on the surface. The latter is due to two errors ; either the component is too hot or the brush contains too much bonding solution. Time should be given for the volatile solvent to disperse gradually and an even matt finish should be the goal.

Of the two types of spraying devices (i.e. air pressure and air volume), the latter has been found most effective for dealing with large surfaces. It may be useful to remember, however, that a circular movement assists in keeping the molybdenum disulphide particles in suspension in the spray container. It is possible with very little practice to produce by spraying a very thin even matt surface.

When parts are coated by dipping, the volatile dipping liquid will quite quickly evaporate, due to temperature rise. This loss must be made up from time to time by the addition of further solvents. Final inspection before curing will ensure that all areas to be bonded are adequately covered.

Fig. 6—Applying a molybdenum disulphide dry film bonded coating from a self-pressurised container

It is important that the components are allowed to air dry before the curing operation. A too early attempt to cure can result in the components being marked during the handling from the curing bench to the oven.

(4) *Stoving.*—Stoving will now be considered as the next operation after the completion of the dry film bonded coating. Below are listed a number of important points which will be found helpful to the progress of the job :

(*a*) Make sure solids of the bonding solution are always thoroughly dissolved and that the molybdenum disulphide particles are sufficiently agitated before application.

(*b*) When placing bonded parts in the curing oven it is essential that the parts are so arranged that the soft newly applied film is not scraped or damaged : at this stage the bonded film is still soft.

(*c*) An allowance should be made for heavy parts to reach their curing temperature before the curing time is measured—for very large components up to an hour (or more).

(*d*) Curing temperatures and agents (bonding) should be selected to ensure that no interference with the heat-treatment of the parts results where the components have received their final heat-treatment.

(*e*) Care should be taken when heating parts to curing temperature : if this stage of the heating is too rapid (temperature rise) distortion of the component can occur.

2kW to 3kW of heating capacity (air circulated), are adequate for small components. Larger and heavier components would require more heat in order to avoid waste of time in attaining curing temperatures.

PRESENT AND FUTURE DEVELOPMENTS

A recent development resulting in considerable applicational simplification has been the provision of the spray-applied dry film bonded coating from a self-pressurised container (Fig. 6). As it was desired originally to provide this type of appliance for use without heat bonding the early efforts in this direction were beset by difficulties caused by rapid drying of the bond and resultant clogging of the very small jet. These have since been overcome and a very satisfactory aerosol is now available. Pretreatments are nevertheless desirable for optimum results.

Reference to Table II will reveal a self-etching bonding agent. This development arose as a result of efforts to simplify the method of application. The results so far obtained using experimental " self-etching " bonding agents are comparable with the most effective bonded coatings used on separately etched surfaces. Generally these results showed up rather better than those obtained with existing bonding agents used on plain machined-finished parts (un-pretreated).

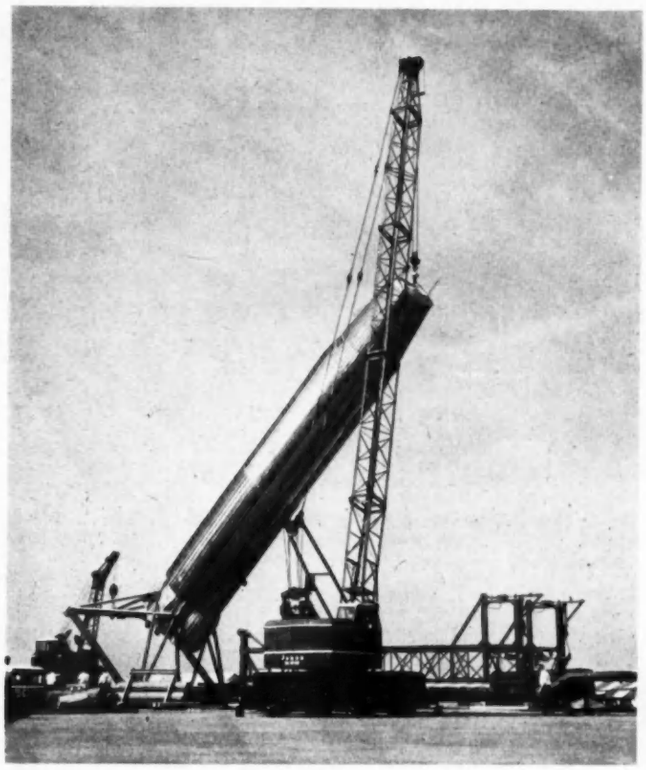
Future developments include bonded coatings for use in the temperature region of 1500 deg. to 2000 deg. Fah. Progress is being made along these lines.

Molybdenum disulphide dry film bonded coatings are not the answer to all unusual lubrication problems even where dry or semi-dry applications are essential. Neither does molybdenum disulphide attempt to compete with conventional lubricants where good service is obtained. Rather it should be regarded as a supplement to the existing range of fine conventional materials and as a " solid lubrication and surface conditioning treatment." Specialist assistance is always recommended.

S.B.A.C. Exhibition, 1961

No. I

The twenty-second Flying Display and Exhibition of the Society of British Aircraft Constructors is being held at Farnborough this week and next Sunday. Below we commence an account of the exhibition, which was the occasion for the first public appearance of the D.H. "Blue Streak" seen here.



THE 1961 Flying Display and Exhibition of the Society of British Aircraft Constructors commenced last Monday at the Ministry of Aviation aerodrome at Farnborough, Hants. This year, as last, the Flying Display was principally a display of flying rather than a demonstration of new aircraft, so that a brief account of those events of the display that are of technical interest appears after a description of the new aircraft.

The one example of a new aeroplane intended for production in quantity is the "Beagle" B.206 of British Executive and General Aviation, Ltd., a twin-engined executive aircraft of, as our photographs show, rather Continental appearance. The significant features of the design are the wide cabin, with three seats abreast in the rear, and the placing of the pilot forward of the leading edge, with a wide view through a large plastics window curved in three dimensions. The back of the centre one of the rear seats is part of a door which hinges back to give access to a toilet, below which is a luggage compartment the two-part door of which forms steps to give access to the cabin door, which is opposite the rear seats on the port side. While the standard five-seat interior has been described, various other arrangements are specified, such as a seven-seater with the three seats abreast facing aft and an ambulance with a stretcher each side. In terms of navigation and communication equipment the B.206 is equipped to "full airways standards."

The "Beagle" B.206 in flight at Shoreham; this is a hand-made prototype, accounting for irregularities in the fit of panels and the uniformity of leading edges. Notice the low-set pivots of the area-increasing double-slotted flaps. The top of the instrument panel is straight to afford a horizontal reference for the pilot

The machine which took part in the flying display, however, had none of these interior schemes, being the recently constructed prototype, and was also unusual in being one of the rare participants in the flying display to use foreign engines; it has two Continental IO-470-D flat sixes of 260 h.p. each, which in production aircraft will be replaced by geared GIO-470-A units of 310 h.p. built by Rolls-Royce, Ltd.—it is anticipated that the price of the engine will be closely the same, so that the amount of the import duty will be saved, while the second source engines are expected to be at no disadvantage in respect of permitted time between overhauls. The engines have McCauley variable pitch propellers with fluid de-icing, and are installed in deep cowlings, which also house the main wheels, with ejectors each side to induce cooling air. The use of turbine engines was considered but relegated to subsequent machines, since the only engines at present available are twice as powerful and costly, and it was considered that the market for aircraft costing over £30,000 each was disproportionately small.

The straight, tapered wing is thinned down from N.A.C.A. 23018 at the root to 2412 at the tip; keeping the maximum thickness no further back than 30 per cent at the root was deemed satisfactory for the speed range of this airframe, and minimised centre of gravity travel as the fuel in the wing tanks burns off—while it is envisaged that later versions will be faster than the B.206, which cruises at 230 m.p.h., the airframe would limit them to a never-exceed speed of about 350 knots (400 m.p.h.). Inboard of the long ailerons are double-slotted (i.e. with one slot built-in) flaps.

The fuselage is dominated by the cabin, which, as has already been described, is large for an aeroplane of this size; there is an equipment bay giving on to the front of the instrument panel and a baggage compartment behind the spar carry-through. It is considered that it would be practical to pressurise the accommodation to a differential of about 3 lb per square inch if it

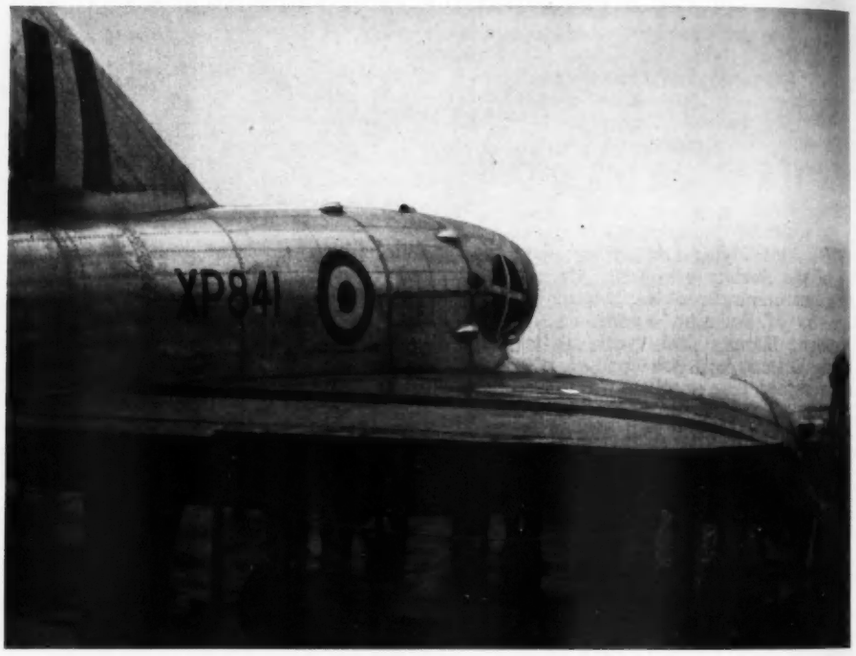
The shadows show that the B.206 has unswept horizontal surfaces. The extensively glazed cabin has room for two pilots, three passengers opposite the door and a toilet at the rear

became desirable ; there are no opening windows, not even for direct vision for the pilot. The fuselage extends back to beyond a straight tailplane and elevator and swept fin and rudder ; the prototype has a variable incidence tail pivoting about the leading edge, but since only about 3 deg. of movement is needed the small anti-balance tab will probably be used for trimming. The sweep of the edges and hinge line of the vertical surfaces is not strictly necessary or optimal, but is included to avoid a conspicuous modification in subsequent variants flying faster and higher.

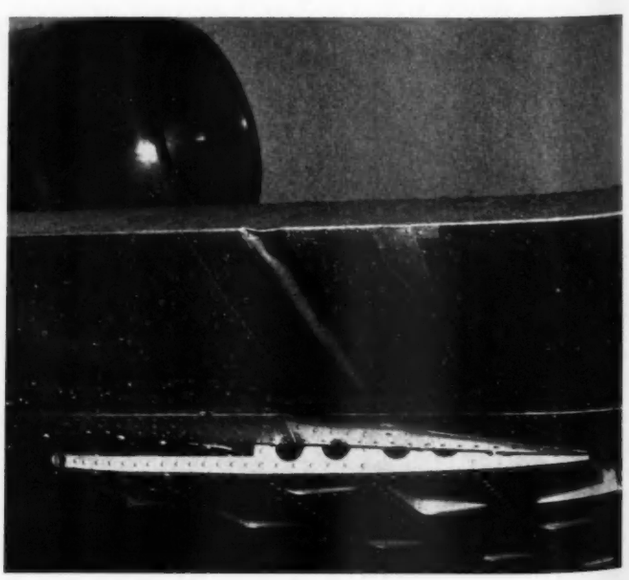
The B.206 was demonstrated from Shoreham aerodrome last week, and flying lightly loaded was shown to be aerobatic as well as agreeably quiet. It is intended to tool up thoroughly rather than to produce the early numbers largely by hand, and it is predicted that deliveries will begin in early 1963.

Another new " Beagle " prototype is the Auster A.O.P. Mark XI, which differs from the present Mark IX observation aeroplane in that the 173 h.p. " Cirrus Bombardier " inverted four-cylinder engine has been replaced by the 260 h.p. Continental flat six, giving a 50 per cent increase in power. Since the airframe has not been altered to any extent, the gross weight is little greater (4 per cent) and hence the take-off performance is vastly improved ; at an all-up weight of 2550 lb the initial rate of climb is 1330ft per minute, and the distance to 50ft is 268 yards (although this is 100 yards more than the definition of a " short " take-off, i.e. 500ft). With this enhanced power-weight ratio, the performance remains favourable in hot and high-altitude conditions, although the engine is unsupercharged. The new engine has an overhaul life 50 per cent greater than the British unit, and it is expected to have an appeal to the operators of the existing machine.

The exhibition provided the first opportunity to inspect the Handley Page H.P.115 low-aspect-ratio delta. The machine is illustrated in the accompanying close-up photographs which show the absence of any curvature of the leading edge, and that the leading edge is not part of the structure but a fabric-covered extension. The square-cut projection below the centre section is simply a structural feature needed to resist hogging moments in a heavy landing. The flight demonstration confirmed that, as theory requires, the machine has high induced drag ; the take-off run was protracted and the rotation and climb-out were very gentle. It is understood that, at the moderate angles of attack which have been used up to date, the control responses have been quite satisfactory to the pilot.



The H.P.115 from one wingtip ; notice the tabs on the elevons and, in the shadow below the wing, a strength member of box section

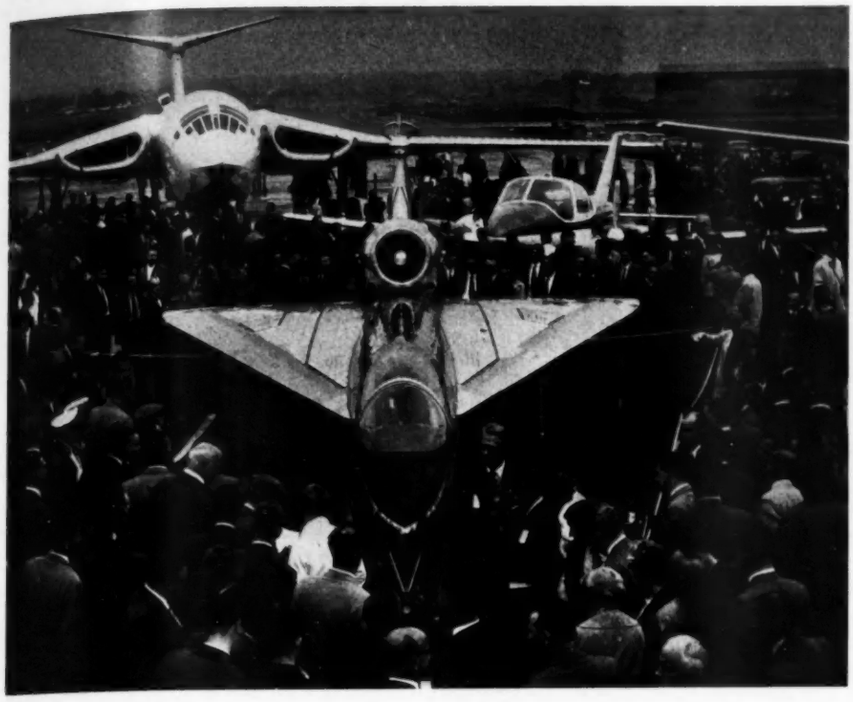


The leading edge of the narrow delta is not part of the structure and is fabric covered. Notice that part only of the air brake fits inside the wing

Missiles

The most prominent missile displayed was of course the D.H. " Blue Streak," the abandoned ballistic missile that is envisaged as a booster for high performance step-rockets. Our heading illustration shows that the development of an erector has, reasonably enough, also been abandoned ; the elaborate special trailer is however essential as it is used as a strut to impose a tensile load on the rocket (details were given in our article on page 431, September 9, 1960). The cylinders of nitrogen with which the shell is stabilised before release from the trailer can be seen in the photograph.

In contrast, the main new disclosure with regard to the Avro " Blue Steel " was a transporter-manipulator to carry the missile close to the aircraft and place it on a low trolley that can be wheeled under the air-



This view suggests that the superficial nature of the leading edge can be exploited to vary not only the section but the plan, particularly the sweep-back. In the background another Handley Page is conspicuous

craft. The manipulator is built on a sub-frame mounted on the chassis of an A.E.C. "Mandator," and controlled from a stand beside the missile ; while the levers for all motions move in the same sense, each one has a differently shaped knob.

A new and relatively small vehicle to carry and launch the big "Malkara" anti-tank weapon has been evolved by Fairey Engineering, Ltd.; it carries two missiles which are raised up clear of the superstructure before firing. This low-height feature is probably dictated by the restricted height of the hold of the Armstrong Whitworth "Argosy" C.1.; models on the British Aircraft Corporation stand showed that the launcher for "Blue Water," a four-wheel-drive "Big Bedford," will go in to the "Argosy" only unloaded and in a form, believed not to be standard, with an open cockpit for the crew. These models also showed that the "Blue Water," like the same maker's "Thunderbird," is transported dismantled and assembled in the field. A largely genuine "Blue Water" is illustrated here. While the engine was not visible, there seems no reason to contradict our earlier report that this relatively short-range vehicle is guided simply by the control surfaces roughly halfway along its length, the large fins at the tail serving to stabilise it as it gathers speed : the leads running back to the boat-tail in the photograph would not seem heavy enough to move a flexible connection between combustion chamber and nozzle.

While only a dummy "Red Top" was shown, on the same stand there appeared the D.H. "Spartan" I, a storable liquid propellant (amines and nitric acid) rocket motor based on a Thiokol design. This motor, which bears a cruciform of wing roots and sets of dogs for transport joints at each end, would seem to be the propulsion section of "Red Top," which is described as a logical successor to the "Firestreak," since the aerodynamic configuration of the latter is closely the same as that of vehicles such as "Thunderbird" and "Seaslug" which were originally laid out for liquid propellants. However, the outstanding limitation of "Firestreak" when used in conjunction with the same maker's "Sea Vixen" is the inability to make collision interceptions, so that, as explained in our description of the new weapon, it may be inferred that it is intended to home on hot exhaust gases.

While not strictly missiles, there may be mentioned also the Bristol Siddeley PR37, a small (170 lb thrust) kerosene-h.t.p. rocket developed to extend the performance at altitude of the "Viper"-engined "Jindivik," and the "Jaguar," a three-stage solid-propellant rocket developed by the Weapons Research Establishment and the Royal Aircraft Establishment.

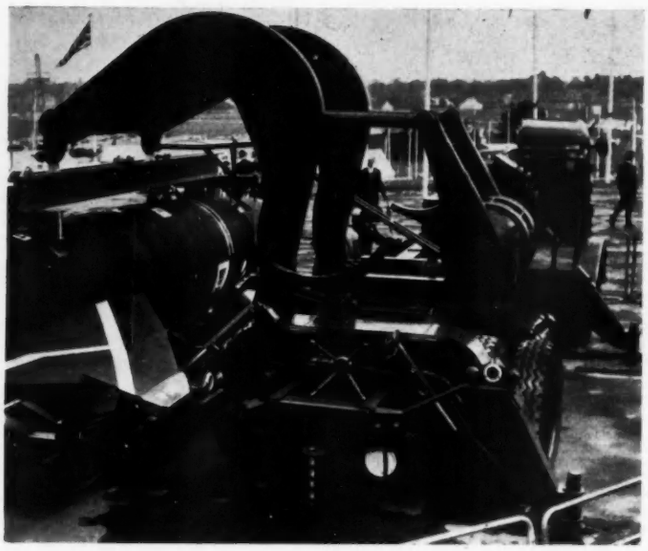
Flying Display

On Monday, the Press day, low cloud shrouded the aerodrome and much of the rest of the country, and the flying display was heavily curtailed. The Royal Air Force contribution was abandoned ; a squadron of all-weather fighters was standing on the apron, but while the "Lightning" aircraft could have taken off, and intercepted an intruder flying above the clouds, the present status of blind landing equipment is such that only for serious operations would the pilots be committed to landing in such restricted visibility. The Royal Navy were also handicapped, since the "Sea Vixen" and "Gannet" aircraft were being operated from H.M.S. "Hermes" in the English Channel, where the cloud base was 300ft and the visibility only ½ mile, and in such crowded waters for the carrier to steam at high speed for flying off and landing on was undesirable ; reduced numbers of aircraft were therefore operated. The Army Air Corps were able to operate helicopters, but parachute dropping was obviously too dangerous in such a crowded area.

The Royal Navy contribution included a photographic sortie from Farnborough by a "Scimitar"; the strike fighter found H.M.S. "Hermes" in the Channel and brought back a photograph showing the carrier flying off her aircraft, with her great radar scanner "looking" at the reconnaissance machine. Another "Scimitar" made the only fast pass of the day, flying very low, and demonstrated the aerodrome arrester gear developed by R.A.E., Bedford, and the Dunlop Rubber Company, as a protection against overshooting by engaging its hook with the single arrester wire almost at the point of touchdown ; the gear is designed to stop a 30,000 lb aircraft is about 600ft, and can be reset—i.e. the cables rewound—in ten minutes, though the discs forming the energy sink may take longer than this to cool. This was the first public demonstration of this device, and we are not at this stage in a position to explain how the hook is able to engage a wire that has been traversed by the main wheels of the undercarriage.

Other Royal Navy demonstrations were of Flight Refuelling on the "buddy" (two similar aircraft) system, a pair of "Sea Vixen" fighters flying past joined by a short hose—less than an aircraft length—and

This photograph shows that a "Blue Steel" fits partly into the big stores bay of a "Victor" Mk. II, and that there is ample clearance between the missile and the engine bays. Later aircraft will not have leading edge flaps



(Left)—The "Blue Steel" is brought to the dispersal point by an automotive transporter; the missile is transferred to a trolley by the large worm gear conspicuous on the right. (Right)—The transporter is settled on to its retractable feet by compressing the road springs with the linkage seen here; above the ram is a beam extending to the other end of the spring and below it is a link pivoted near the axle

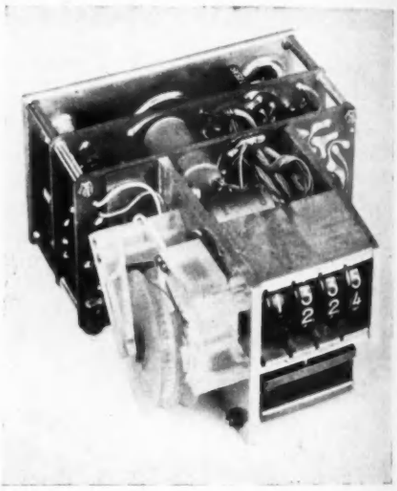
formating extremely steadily, and of formation flying by Fairey "Gannet" early warning aircraft, four machines feathering their front propellers simultaneously while in close formation.

The Army Air Corps flew eight "Skeeter" helicopters which performed "air drill" or aerobatics; for much of the time pairs of aircraft or formations of four were flying respectively past or through each other on reciprocal courses at the same height.

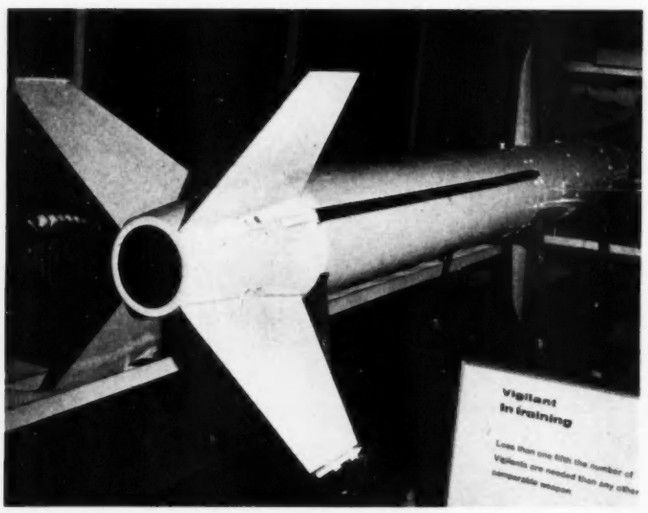
The helicopters of Westland Aircraft, Ltd., were also able to perform, and the largest, the "Wessex"—development of the "Westminster" is not continuing, presumably because the S.64 has reached at least equal status—demonstrated hovering on autostabilisation with a "dunking" sonar lowered and also towed a heavy vehicle with loaded trailers. A "Whirlwind" with a "Gnome" (T-58) engine carried and set down a Citroen 2 c.v. van, and a "Belvedere" (the erstwhile Bristol 192) landed a platoon of troops. A "Scout" with a Blackburn "Nimbus" engine also took part.

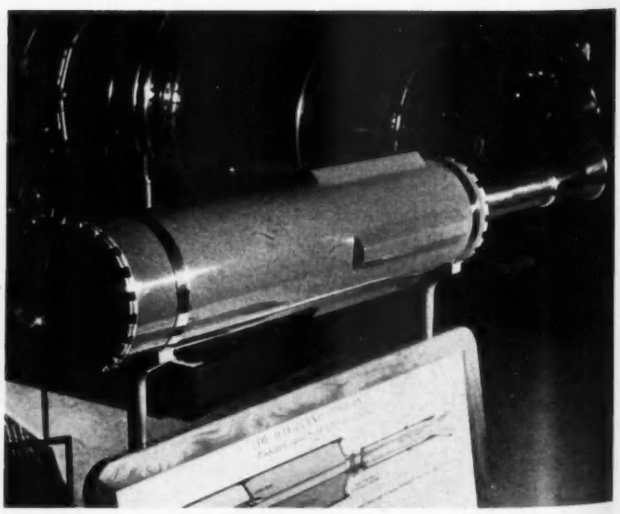
The weather did not, of course, prevent the Short S.C.1 from flying; as last year, the machine took off from an elevated steel platform, but after a short demonstration that included flying sideways quite steadily, it landed on a taxi track. It may perhaps be interpolated here that experiments by Rolls-Royce, Ltd., have shown, according to displays at Farnborough, that nothing more than an aluminium plate immediately opposite the nozzle is necessary to hold down to a tolerable amount the erosion of a grass field during a vertical take-off, and also that a take-off can be made quickly enough for hot exhaust gas not to reach the intakes.

A not unrelated demonstration was given by Martin Baker Aircraft, Ltd., an ejection seat mounted on an eight-wheeled truck and occupied by a dummy being fired at "zero (height)–zero (speed)." In the poor light the flare of the rocket accelerating the seat upward was clearly visible; the drogue and parachute are deployed while the seat is still climbing, or rather falling upwards, so that the first effect of the parachute is to accelerate the seat downwards. When the parachute is opened the seat itself is allowed to hang some way below the pilot, whereas if it was



The resistive element of this self-balancing potentiometer is a plastic tape, and the length transferred from one spool to the other is counted in terms of perforations and presented in digital form





(Left)—A "Blue Water" bombardment missile; flares appear to be fitted at the tips of two of the fins, possibly only for trial purposes. The exhibit is not sufficiently complete to establish that the propelling nozzle is fixed. (Right)—The D.H. "Spartan" I is based on a Thiokol design; the combustion chamber takes the form of a long tube which is contracted only slightly at the nozzle and is coated with a ceramic like alumina

released completely it might fall on either parachute or pilot. The seat was fired facing down a light wind, and the parachute landed a few yards behind and to one side of the truck.

Static Exhibition

Among the exhibits of Bryans Aeroquipment, Ltd., were high performance temperature indicators incorporating digital display to the nearest degree. These instruments were developed by the B. and H. Instrument Company, Inc., of Fort Worth, Texas, for measurement of turbine inlet and exhaust gas temperatures, and read up to 1200 deg. Cent. with a rate of follow-up of 150 deg. Cent. per second. The input, a voltage of not less than 20mV for full scale deflection, is transformed to digital form in a highly direct manner ; the self-balancing potentiometer net uses as its variable resistance a tape of " Mylar " which is perforated and driven from one to the other of two spools by a sprocket which is geared to a counter mechanism. The sprocket has tapered teeth, so that any departure from linearity can be corrected by varying the spacing of the perforations (to 0·001in order). The movement illustrated is that of an industrial instrument, but there are also available large and small circular clamp-fitting instruments which have in addition a pointer sweeping a circular arc scale to give an " appearance " presentation. Additional facilities are a warning light, with press-to-test provision, that appears within 10 deg. Cent. of a point pre-set at the factory, and a power supply failure warning. The instrument is hermetically sealed and contains an atmosphere of nitrogen, but it is interesting to note that it can be sealed without the use of any special tools and that the trimming resistors are accessible without breaking the seal. The instrument can contain the cold junctions and temperature correcting circuits, even in its smallest version, but to allow copper leads to be used in, for instance, missile umbilical connections it may be desirable to mount the cold junctions and compensator nearer the origin of the signal. The indicating instrument itself is of course adaptable to use with transducers of a wide variety of physical quantities.

(*To be continued*)

Automatic Watch

By T. R. ROBINSON

The first application of automatic winding to wrist watches was by an English watchmaker, John Harwood, in 1927, *and from his basic design there have been developed the many efficient automatically-wound watches of to-day. Modern trends in design even suggest that such winding mechanism may become a standard fitting to all spring-driven watches in the future. In this article details are given of the first British-made automatically-wound watch to go into full production.*

THE so-called " automatic " watch, in which a weight, pivoted out of balance, is used to convert the changes of position of the watch arising from the movements of the user into power to wind the mainspring, has now become so popular that practically every notable maker has at least one model of this type in production. The first British-made model of this kind to go into production has just been marketed by Smiths Clocks and Watches, Ltd. This watch embodies most of the latest trends of design, such as a rotor-weight which can move through a full 360 deg. in either direction to operate the winding mechanism, and a cam-and-ratchet linkage between this rotor-weight and the gearing which winds the mainspring.

The watch, designated as " Calibre 0144G," has a time-keeping train and escapement which conforms to accepted modern practice, and is, in fact, identical with that of the firm's hand-wound " Calibre 0104," which has been in production for some time and was originally designed as the basis of the new automatic model. The component parts of the new watch and their arrangement can be seen in the illustration overleaf. Its seconds hand is concentric with the hour and minute hands, and the lay-out of the wheelwork of the timekeeping train is such that the fourth wheel, the spindle of which carries the seconds hand, is located in the centre of the movement, with its spindle passing through the hollow centre-wheel spindle. The elongated front pivot of this fourth wheel spindle projects beyond the minute hand on the dial to receive the seconds hand. This method of drive (known to horologists as an " out-and-back " arrangement), although it entails considerable modification of the older form of train arrangement, has the advantage that it gives a more precise control of the seconds hand, which, being mounted on the end of a spindle forming part of the watch train, moves forward evenly and precisely. When the central seconds hand is mounted on an additional spindle that forms, so to speak, an " outrider " to the main train, a tendency sometimes develops for the hand to move forward in irregular jumps as a result of backlash in the gearing, a defect which impairs the usefulness of the reading given.

The escapement is of conventional lever form with a club-toothed escape wheel, and a balance with pivots running in jewel holes set in shock-absorbing settings. The balance-spring, or " hairspring," is of flat-coil form, and is made of a non-magnetic alloy. The mainspring, which is housed in a going barrel of conventional form, is of " Permalife " alloy, and is capable of driving the watch for about forty hours when fully wound. In order to meet the special requirements of automatic winding, the outer end of the mainspring is not attached to the inner surface of the barrel wall by the usual form of hook. It is coupled to the barrel by an additional slipping-spring that permits the mainspring to slip round in the barrel if further winding effort is imparted after it has reached the fully-wound condition.

Conventional keyless hand-winding is provided to serve as a standby and enables the watch to be wound by hand if it has been out of use for long enough to allow the mainspring to run right down. The mechanism also embodies the usual means of hand-setting and the " keyless work," as it is called, is of a very rugged type, every effort having been made to avoid the use of small springs and other parts liable to fracture from fatigue or mis-handling.

The automatic winding mechanism is built up on the back of the train frame-bar, which is of particularly sturdy form to enable it to carry the additional assemblies without risk of distortion. The rotor-weight is a sector-shaped component, at the pivot point of which is inserted a steel eccentric cam. Inside this cam is fitted a ball-bearing, consisting of five steel balls, held captive in a minute cage of normal ball-bearing design. The stationary portion of this ball-bearing takes the form of a stout steel pillar, rising from a plate attached to the train frame-bar by three screws.

This form of bearing possesses ample strength to resist quite appreciable shocks, and at the same time acts with sufficient freedom and smoothness to permit the rotor-weight to perform its winding function during very small movements of the wearer's wrist. In addition, the bearing is so constructed that it can be easily and very precisely adjusted by turning the central screw

The new lightly armoured air-portable launcher vehicle for the " Malkara " anti-tank guided weapon, which can knock out the heaviest tank at a range of two miles

that retains the rotor in position on its pillar. Any unintentional alteration of the adjustment is prevented by two in-pointing lugs in the central hole of a chamfer-edged spacer that is interposed between the rotor and its retaining screw. These lugs engage with two slots cut in the outer end of the steel pillar on which the rotor turns. Removal of the central screw permits the complete rotor unit to be detached from the watch.

The method by which the movements of the eccentric cam are used to propel the winding mechanism is simple but ingenious. Pivoted between the back of the train frame-bar and a small additional bar is a small sub-frame, consisting of two plates, united and spaced by a pillar. At the remote ends of the plates are two projecting members which embrace the eccentric cam on the rotor, and between each pair of projections

Exploded view of Smiths "Calibre 0144G" automatic watch

is pivoted a roller-shaped jewel, both these roller jewels being in contact with the cam contour. The movement of the rotor and its cam therefore causes the small sub-frame to rock on its pivots.

Between the two plates of the sub-frame are pivoted two specially-shaped pawls, the acting ends of which engage with the teeth of a steel ratchet-wheel that pivots between the train frame-bar and the previously mentioned additional bar. One of the pawls is considerably longer than the other, and has a right-angled projecting tail, to which is attached a light pawl-spring. The free end of this pawl-spring engages with the side of the shorter pawl in such a manner as to hold both pawls into contact with the ratchet-wheel teeth with equal pressure.

As the movements of the watch cause the rotor to turn on its pivot, the eccentric cam will rock the small sub-frame on its pivots, and so cause the two pawls, acting in concert, to propel the ratchet-wheel forward, tooth by tooth. It is, of course, quite immaterial which way the rotor moves, for movement in either direction will rock the sub-frame. The advantage claimed for this cam form of winding is that changes in the direction of rotation of the rotor, however rapid, cannot cause damage to the winding mechanism. Also, as the rotor is free to move round a full circle, it does not subject its pivot pillar to any reaction shock such as that which occurs when the rotor travel is limited by buffers.

On the underside of the ratchet-wheel is a small pinion which engages with the transmission wheel of the winding-wheel assembly, and in this way the rotation of the ratchet-wheel winds the mainspring through the same wheels as the winding stem and button. The step-down reduction ratio between the rotor movements and the final winding wheel permits the energy imparted by the rotor to wind the mainspring with ease.

When the mainspring reaches the fully-wound condition, which is fairly soon with normal wrist movements, any further operation of the winding mechanism winds the additional spring on the outer end of the mainspring, and so slackens its grip on the going-barrel wall. This, in turn, enables the mainspring to slip round in the barrel and avoid any overstrain of the mainspring itself. As soon as the surplus power has been expended by the slipping action, the additional spring again grips the barrel wall and the cycle is repeated. In normal circumstances, the result is to keep the mainspring in a fully-wound condition, and the even power output from the spring has decidedly beneficial effects on the time-keeping properties of the watch.

It may be mentioned that there are two schools of thought concerning automatic winding, one of which favours a high ratio of about 200 to 1, and so takes advantage of very small movements of the rotor, and the other which selects a lower ratio of about 50 to 1, an arrangement which requires larger movements of the rotor to propel the mechanism. In the watch under discussion, a high winding effort in excess of normal requirements was adopted.

One further small component mounted in the rocking sub-frame is a pawl-raising cam, which is located between the pawls, and is used to lift both pawls clear of the ratchet-wheel and to retain them in this position. The cam is of dual design, and consists of a twin-cammed steel block which pivots between the two sub-frame plates and is provided with a projection which passes through a hole in the top plate. A screw-slot is cut in this projection and, using this slot to turn the cam, the two pawls are disengaged from the ratchet-wheel. The reason for the provision of this disengaging device is that the tension of the dual-action pawl spring is very critical, and must not be interfered with. When the pawls need to be disengaged, as, for instance, when adjustment of the rotor bearing is required, it is only necessary to turn the screw-slot on the projecting portion of the cam from "IN" to "OUT" in order to lift both pawls without any alteration to the tension of the pawl spring. Both the "IN" and "OUT" positions of the cam are indicated by words and pointers engraved on the top plate of the sub-frame.

The "Calibre 0144G" is made to very high standards. Both the timekeeping train and the winding mechanism are jewelled at all essential points—there being twenty-five jewels in all, each being essential and functional. The frame, rotor, and other parts are nickel-plated and damaskeened, and the steel parts are highly polished.

OBITUARY

G. R. THURSFIELD

We regret to record the death of Mr. G. R. Thursfield, formerly chairman of the Sturtevant Engineering Company, Ltd., which occurred on August 26. Greville Richard Thursfield was born at Broseby, Shropshire, on January 17, 1874, and educated privately in England until he was fourteen. He then went to the Technical School in Vienna before going on to the City and Guilds of London Institute to complete his studies in electrical engineering. Returning to Austria, he spent several years in the Thursfield Engineering Works at Gumpoldskirchen, and in 1898 joined the Sturtevant Engineering Company, of London, in a relatively junior capacity. Mr. Thursfield rose rapidly in the Sturtevant organisation, managing the company's Berlin office for several years in the early part of this century, and being appointed chief engineer and director in London in 1915. In 1941 he became chairman and managing director, retiring from the post of managing director in 1951 and relinquishing the chairmanship in 1958.

Mr. Thursfield was deeply interested in the Bifurcated Rivet Company, of Aylesbury, and among other important directorships he held were those of the Crosby Valve and Engineering Company, Ltd., and the Igranic Electric Company, Ltd. He was a founder member of the Institute of Fuel, a Fellow of the Institute in 1928, and a vice president in 1941.

Nuclear Electronics Symposium

The Measurement and Control Section of The Institution of Electrical Engineers is arranging a Symposium on Nuclear Electronics, to take place on November 30 and December 1 next at Savoy Place, London, W.C.2., which is intended to follow up the conference on the same subject held by the International Atomic Energy Agency in Belgrade in May of this year.

The Belgrade Conference was attended by delegates from more than thirty countries and is considered to have been the largest and most successful international conference on the subject which has yet been held. The symposium which the Institution is now arranging, after consultation with the International Atomic Energy Agency, is intended to give an opportunity for those interested in the subject in this country, and particularly for those who did not attend the Belgrade Conference, to hear and discuss reports on the material presented there.

The Symposium will consist of three sessions, dealing respectively with "Radiation Detectors," "Electronic Circuits and Techniques" and "Radiation Monitors and Instruments." At each session a report on the subject matter of the relevant papers presented at Belgrade will be given, after which other speakers will either deal in more detail with subjects which they themselves presented there, or give their own appraisal of the impact of the Belgrade Conference on current researches in this country. At the end of each session there will be an opportunity for the discussion of all the material presented.

Registration forms for the symposium can be obtained from the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2. The registration fee (to be sent with the registration form) is £1 for members of The Institution of Electrical Engineers, and £1 10s. for non-members of the Institution. All registrants will receive a set of abstracts of the material to be presented.

THE ENGINEER

REVIEW OF BOOKS

SEPTEMBER, 1961

FUNDAMENTAL PRINCIPLES OF POWDER METALLURGY

W. D. JONES

Publishers: Edward Arnold, Ltd., 41, *Maddox Street, London, W.*1. *Price* 147*s.*

THE quantities of engineering components made by metal powder processes are acknowledged to be on the increase. Considerable effort is being put into fundamental and industrial development and interest in results obtained is considerable as evidenced by the very good attendance at symposia. This being so, this book makes a very useful contribution for it is a very comprehensive review of published work relating to all aspects of the subject. The author states that the book has been written for science graduates with the aim of providing a full and broad picture of the fundamentals. This is a very fair, even modest, claim and the aim has been very competently accomplished. The book will undoubtedly appeal primarily to metallurgists but engineers will also find it a very useful source of background knowledge.

Dr. Jones's earlier book, *Principles of Powder Metallurgy*, has not altogether been superceded by the new work. The earlier book was more concerned with codes of practice whereas the new one, whilst containing a great deal of practical information, deals to a large extent with the theories and explanations of the mechanisms of the various processes. In the original book, details of the manufacturing schedules and practices are given but in the new book these details are quoted as illustration during the discussion of each aspect of the process.

The book is divided into seven chapters of varying length. The first chapter (239 pages) covers the principles and preparation processes of metal powders. The underlying theory of preparation from oxides, fused salts, precipitation from gas or vapour phases, and preparation by mechanical means or from liquid metal is discussed. This includes some details of the particular characteristics of each method and of the powder produced. Description of industrially used processes is also given. Whilst most component manufacturers buy their powders a consideration of the methods by which they are made is useful as it aids an understanding of their limitations. This chapter should enable a user to talk the same language as his supplier of raw powders.

The second chapter, on pressing (109 pages), first considers in detail the packing of powders in die cavities and the factors relating to the welding which occurs during the application of pressure. Die wall friction and its effect on pressure distribution throughout the compact are considered, sections are devoted to lubrication and available lubricants enumerated, together with factors affecting their selection. The consequences of elastic deformation in relation to ejection forces and compact expansion on ejection are discussed; a section on die and press design follows. Typical pressing procedures are instanced and press types quoted with advantages, &c. Special features of press design to improve particular aspects of the process are also listed. A section describes the principles of isostatic pressing and the methods currently practicable. The use of explosives is briefly mentioned. Further sections cover the influence of powder characteristics on pressing, and hot pressing techniques, including the methods of obtaining the necessary temperature. The difficulties of hot pressing make it an unsuitable process for rapid production, but suggestions are offered for future research towards this object. Two final sections on the use of very high pressures and on historical background conclude the chapter.

Shaping without pressing occupies Chapter III (fifteen pages). Methods of shape forming are considered.

Chapter IV (217 pages) deals with the sintering process and is an exposition of the mechanism and theory. Rapid changes in density occur very early on in sintering, the importance of Van der Waals force, repacking caused by boundary slip and by change of particle shape is discussed. The considerable gaps in this aspect are highlighted. The researches on densification are well reported. Some mention is made of the sintering of non-metallic substances. A summary of practical deductions from consideration of theory is given. Sintering of dissimilar metals when both are solid, reactions in the presence of a liquid phase and combinations of oxides or carbides and a liquid metal are reviewed. A large number of industrial systems such as porous bronzes and tungsten carbide/cobalt alloys are examined, manufacturing details and sintering behaviour are discussed. Infiltration techniques are illustrated by reference to iron and tungsten carbide. Other topics discussed include bonding in polyphase compacts, the consequences of contamination with special reference to gases and the effect of impurities as an obstacle to the sintering of iron alloys. Sintering furnaces, temperatures and atmospheres are also considered as separate sections.

The chapter on specific qualities (321 pages) describes, in detail, industrial products which are particularly suitable to powdered metal manufacture and make use of the natural characteristics of the process. As an introduction to this chapter the peculiarities of metal-powder-produced parts are enumerated and the influence of processing variations or special additions on mechanical properties is discussed. Nine fields in which powdered metal is in use are discussed in great detail; these encompass such products as "ferrites," ceramic magnets, porous bearing frictional materials, sintered aggregates such as silicon/cadmium contacts and diamond tools. A substantial section of this chapter is devoted to the competition between conventional and powdered-metal-made components. The economics of the various operations and ways of lowering costs are discussed in some detail. Reference is made to iron and in this case one of the chief obstacles to wider use of powder metallurgy in the ferrous field, that of strength, considered in relation to alloying and other methods of strength improvement. Costs again are considered as a basis for selection. A section considers the compromises of cost and required properties and shows that in powdered metal parts, as elsewhere, attainment of specific qualities has finance as a dependant variable.

The chapter on continuous powder metallurgy (103 pages) reviews the problems and difficulties encountered in forming powder continuously into strip. The various systems and handling difficulties are discussed. Reference is made to nickel strip which when formed by continuous compacting has properties which are superior in some respects to cast and rolled material.

The final chapter (forty-five pages) deals with control tests on powder, green and

REVIEW OF BOOKS *(Continued)*

sintered compacts and other special tests. This chapter is somewhat less detailed than the preceding ones and perhaps suffers from the fact that it was written before the symposium on the subject of testing was held in London in the spring of this year. Obviously the author has to draw the line somewhere but having set such a comprehensive standard of review an occasional revision will be necessary in order to maintain the quality of the book. However, the present volume should serve as a standard reference for some years.

The author has used historical background and quoted development of theory and processes so that a sense of perspective is imparted.

Generally speaking the division of the book into chapters and sections is confused and would have benefited by increasing the number of chapters with a somewhat more rationalised system of sub-headings. The references are quoted at the bottom of each page ; it is more usual to quote lists of references at the end of a chapter since this facilitates subsequent reading. A notable feature is that the author has taken pains to point out gaps and discrepancies in the present knowledge and suggests areas where more work could be done. It is likely that the book would be of considerable interest to advanced students but would have been of more value to this class of reader if it had been split into several volumes.

ADAPTIVE CONTROL PROCESSES

A Guided Tour

R. BELLMAN

Publishers : Princeton University Press, 41, Williams Street, Princeton, New Jersey, U.S.A.
Price 6.50 dollars

THIS is more than an important book, it is a milestone on the road of the post-war development of automatic control theory. To see it in perspective one must review briefly the history of control theory during the past sixteen years. At the end of the war the feedback control technique which had been so successful in radar tracking applications was quickly seen to have a much wider significance. Not only was it a unifying principle underlying many diverse engineering devices, but its action could be traced in the nervous system, and even in the human brain. Here indeed was a subject with a bright future. Obviously it was a vast study, and would be difficult. But in 1948 the high speed electronic computer appeared and was immediately seen to be the perfect instrument with which to construct and analyse large scale feedback systems. Numerous applications were soon envisaged, of which the fully automated factory was but a modest example. How much of this wonderful future has been realised? Up to now almost none. Most of the over-abundant literature of feedback control has been a fossilised reiteration of the Laplace transform technique introduced during the war. Instead of the mathematical theory being a tool with which to solve real engineering problems, the engineering problems have been distorted and oversimplified to suit the mathematics. In this situation one could hardly expect significant practical achievements.

New ways of looking at automatic control problems are required, ways more suited to the practical specifications of present day problems, like the fully automatic chemical plant and air traffic control. One very useful new way of formulating some of these control problems has been to use the dynamic programming approach. The term " dynamic programming " first appeared in about 1952 in the papers of Richard Bellman, a mathematician working at the Rand Corporation in California. What is dynamic programming? On page 59 of this book Bellman himself says " dynamic programming is not so much any fixed set of analytic techniques as a state of mind." The knowledgeable practitioner will agree with this, but to be more specific it is a way of choosing values of certain variables so as to maximise, or minimise, a complicated function, or integral. It has similar objectives to the calculus of variations, but is much more general. What is so useful about the method is that the required values are chosen in a step-by-step fashion, using a simple, fixed, rule over and over again. This iterative working is, of course, ideally suited to the high speed digital computer, indeed this is one of the mathematical methods specifically of the electronic computer age. Its scope seems to be unlimited, and Bellman has been the author, or co-author, of over 300 (yes, three hundred) papers, with applications ranging from biological cell processes to space vehicles.

The technique was first applied to control problems around 1955 by Bellman. From then on a few research engineers (later including some in Britain) began exploring its possibilities, and a small number of important papers have appeared. So far the more notable achievements in automatic control are, a really feasible method for designing linear multi-variable systems (Kalman and Merriam III), an exact treatment of bang-bang systems (Bellman, Glicksberg and Gross, Desoer, and others) and a powerful new computational method for noisy systems (to be published shortly in Britain). It is not yet a fully proved technique; much essential " know-how " still has to be gained by experience in varied practical projects. But more interesting than past successes is the promise of a proper mathematical treatment of the adaptive control problem. An adaptive control mechanism will vary its action to cope with unpredictable changes in the characteristics of the plant it is regulating. For instance, a sudden decay in catalyst activity in a chemical plant will demand new operating points. The possibility of such controllers is intuitively obvious, but no exact analyses have been produced.

The present book is an account of the basic mathematical ideas underlying the application of dynamic programming to automatic control and leads up to a discussion of adaptive control. The presentation is in short chapters, written in a delightful anecdotal style which is uniquely the author's own. Simple, clear, mathematical examples are quoted, and the reader is shown how these ideas are a natural extension of the methods of analytical dynamics devised by the great mathematicians of the ninteenth century. All the way through the importance of formulating practical problems so that numerical answers can be obtained, on a computer of realistic size and speed, is emphasised. This is, of course, the main motive behind the method; such considerations of ease of computing are likely to be a major theme of the engineering of our time. Some chapters on applications to communication problems, and to switching and computer logic networks, are added for good measure. The practical engineer will find no descriptions of working devices, but equally there are no spurious mathematical refinements which will not help his understanding of applications.

A user of the technique is likely to find that some of the discussions terminate just as they are becoming interesting, that is when the properties of some of the computing formulae are coming up. To be fair one must say that the author is preparing another book on the computing aspects, but more discussion of, say, the matrix Riccati equation could have been expected. No results of numerical work are quoted, and brief details of the application of one of the approximation methods would surely have been illuminating.

The last half of the book discusses stochastic processes, and leads up to a statement of the adaptive control problem. Only extremely simple examples of adaptive control have, so far, been worked out. Here the difficulties are as much computational as conceptual; even very simple examples require the largest available computers. Quasi-linearisation and other numerical approximation methods suitable for computers are described, and apparently have been tried on the adaptive problem, but no hint of the results is given. Even if these attempted solutions have not been very successful the reader would be interested.

Dynamic programming will surely become a useful theoretical tool in automatic control. In a few months other books written by engineers will become available, but these are unlikely to equal the present book in explaining the fundamentals of the technique, and giving such a wide perspective, or in the author's capacity for making stimulating side remarks, each one of which could be the starting point of an extensive research programme. At least one British university offers a course in dynamic programming to its post-graduate control students, and this book is ideal for the lively student, the annotated bibliography being valuable on its own. At its modest price this book is essential to the research engineer and teacher ; the practising engineer may find it somewhat abstract, but a little perseverance will be well rewarded in the coming years.

NUMERICAL METHODS FOR SCIENCE AND ENGINEERING

RALPH G. STANTON

Publishers : Prentice-Hall International Inc. 28, Welbeck Street, London, W.1. Price 45s.

THE mathematical solution of a physical problem consists of two separate parts : (1) the general analysis of the phenomena ; (2) the attainment of numerical solutions. The object of the first part could well be to observe the effect of changes in the independent variables in order to influence design in the direction of greater efficiency, but to the engineer the solution is rarely complete without the numerical solution.

To the layman this second part would appear to be relatively simple, merely the application of common arithemetical processes with the help of mathematical tables, slide rule and desk calculator. In many problems very simple processes may suffice, and students may be pardoned for thinking that they always will, when they are not taught the techniques of numerical analysis and all the data for their problems are given in "round" numbers. One does, however, realise that the achieving of numerical results is often an enormous problem when one thinks for instance of the optimum design of a steel structure, or the changing aerodynamic characteristics of an aeroplane under a rapidly fluctuating wind load. These problems would naturally call for the assistance of an electronic computer, but there are, of course, a variety of problems of lesser complexity which require skill with hand techniques.

Literature entirely devoted to numerical analysis is not voluminous, and the book under review is welcomed as one specially written for the university student who is already equipped with a good knowledge of algebraic analysis. There is no doubt that a good introduction to this subject is needed. The author is professor of mathematics at the University of Waterloo, Ontario, and the work is the basis of a course given to students of science and engineering.

The contents include interpolation, and inverse interpolation, computation with series and integrals, numerical solution of differential equations, matrices, solution of sets of simultaneous linear equations, difference equations, and a very short chapter on the principle of automatic computers. One notable omission is the analysis of periodic data, but no doubt this would take up more space than was available. From a students' point of view the book is excellent in many respects, the production of the work is good, there are a large number of worked examples and at least 400 (left without answers) as exercises. Many of these examples are, however, not numerical, but proofs or deductions based on the principles given.

The chapter on the solution of equations calls for comment. Graphical methods, iterative methods, and Newton's method are all explained and illustrated. The cases of coincident roots and complex roots are treated in a clear and concise manner. The choice of methods is good and should cover most practical cases satisfactorily. Horner's is mentioned by name, but not used as it has the disadvantage of being restricted to polynomials.

In the chapter on linear equations, relaxation and iterative methods are explained in addition to elimination methods, and there is a useful section on ill-conditioned equations. The method of expressing an unknown as the ratio of two determinants, although explained, is condemned as being practically useless for computational work, and this is backed up by quoting from good authority.

One thing, however, is disappointing : most of the examples appear to refer to pure mathematical functions, and the errors of the computation are merely due to "rounding off." Very little space is devoted to experimental data, actually only eleven pages on the "least square" approximation, and this covers only the case of two variables, one of which is presumed to be correct.

THE ELEMENTS OF HEAT FLOW

D. A. Wrangham.

Publishers : Chatto and Windus, Ltd., 40–42, William IV Street, London, W.C.2. Price 70s.

A PRELIMINARY perusal of this book gives an immediate impression of untidiness and confusion. Unfortunately, a more careful examination only serves to confirm this first impression. It is not simply that the typographical appearance is unpleasant though this is bad enough : many of the pages, e.g. pages 92–93, 98–99, 347–351, are so ugly that it is difficult to conceive of a reader having sufficient determination to tackle them. But should such a reader exist, he will find that little attempt has been made to reward him either by careful argument or by orderly arrangement of the subject matter. The diagrams and calculations have the appearance of having been reproduced almost unedited from a collection of rough notes.

The subject matter of the book would be appropriate to an introductory course on heat transfer at undergraduate level, but the book cannot be recommended for such a course owing to the unsatisfactory treatment of most topics. Even the chapter on units is badly written. The author fails to underline the essential difference between the pound force and the pound mass and, indeed, uses the symbol, lb, for both, ignoring the British Standards recommended symbol lbf for the pound force. The statement "a force of one gram weight is equivalent to 981 dynes" is made without any reference to the gravitational acceleration. The technical terms "unit" and "dimension" are used without definition. Under the heading "Derived Units," the author begins : "Having settled on the fundamental units all other variables can be expressed in terms of these." All other variables ! One proceeds to the subsequent chapters in trepidation.

The various topics related to heat transfer by conduction are dealt with, but there is no attempt to give unity to this branch of the subject. For example, conduction in slabs is dealt with in one chapter, while conduction in cylinders and spheres, which can also be treated one-dimensionally, is dealt with in a separate chapter. Another example of bad arrangement of subject matter is the introduction of the topic of surface heat transfer in a chapter dealing with conduction (chapter 2). The author uses the symbol U for the *surface* heat transfer coefficient, a symbol usually reserved for the *overall* heat transfer coefficient, thereby failing to make the clear distinction which ought to be made. The alternative name offered for the surface heat transfer coefficient, namely "the local individual coefficient of heat transfer" is both unknown and unwelcome to us.

Heat exchangers are dealt with using the "mean temperature difference" method of approach. Whilst this method ought to have a place in any introductory treatment of parallel and counterflow heat exchangers, it is limited in its general usefulness and is being supplanted by the use of charts of the kind introduced by Kays and London. The treatment of heat transfer by convection is superficial and out-of-date ; the term "boundary layer" does not appear in the index. The Reynolds analogy relation is derived, but it is necessary to go forward ten pages before finding any reference to the restriction in its application to fluids having a Prandtl number in the region of unity ; the restriction is then said to be to "gases and liquids of small viscosity." Dimensional methods are all but ignored. The single reference in the index turns out to be an example though the π-theorem is sketchily dealt with later and is separately indexed.

Enough has perhaps now been said for it to be apparent that this is an unsatisfactory book in almost all respects. The only originality of treatment noticed is the absence of the traditional "boiling curve" in the chapter on boiling, a diagram usually regarded as essential in any introduction of the topic. The best that can be said of this book is that the binding and the quality of the paper are good !

FIELD COMPUTATIONS IN ENGINEERING AND PHYSICS

Professor A. Thom and C. J. Apelt.

Publishers : D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 30s.

THE subject of numerical solution of difficult problems in engineering and physics now has an extensive literature of its own and the various techniques of Hardy Cross, Southwell and Thom have their advocates and practitioners. These schools are divided like religious sects and it is unusual for any practitioner to have sufficient experience of the rival methods to enable him to be a fair judge of the possibilities of the alternative techniques. We are in this position also.

It is abundantly clear from a first study of Professor Thom's and Mr. Apelt's book that the technique they propose is capable of yielding very satisfactory results and it may be suspected that in expert hands it will yield these results at least as quickly and accurately as the familiar Southwell relaxation techniques. It appears, however, that to those who are more familiar with Southwell's method, the latter will still prove quicker. Numerical computation done for the first time is always a slow process and the educational period necessary to become sufficiently familiar to obtain worthwhile results in a reasonable time appears to be applicable to the method of Thom as well as to that of Southwell. On the other hand, Thom's method seems, at first sight at any rate, to be more suitable for programming

REVIEW OF BOOKS *(Continued)*

on computers than any other numerical technique known to us.

The book itself, once it has got away from the introductory discussion of the relative priority of the various workers in this particular field, is a clear and straightforward exposition of the principles and techniques proposed. Two critical comments might be made : one that a list of symbols would be advantageous and the other that in several places, e.g. on pages 49, 52 and 54, there is reference forward to what occurs in a later part of the book which to those reading it for the first time, causes a certain amount of loss of continuity of thought. This difficulty disappears, of course, on re-reading. Having set up the techniques, the application of them is illustrated and dealt with in some detail in connection with Laplace's equation, free streamline problems, Poisson's equation, fourth order linear equations, the Navier-Stokes equations, flow of compressible fluid and the various problems with axial symmetry. The authors with refreshing candour point out some of the difficulties into which the neophite may fall and they make no pretence that their method can in any way obviate the drudgery which is involved in numerical solutions to many problems.

To sum up, the book appears to be an excellent reference work for those using this particular kind of technique, but in this, as in most other numerical methods, there is no substitute for practice and this practice should be carried out under the watchful eye of an expert master.

ENCYCLOPAEDIC DICTIONARY OF PHYSICS. Vol. I.

A to Compensated Bars

Editor-in-chief : J. Thewlis. Associate editors : R. C. Glass, D. J. Hughes and A. R. Meetham.

Publishers : Pergamon Press, Headington Hill Hall, Oxford. Price, £98 the set.

THIS is the first volume of a work due to be completed within a few months in seven volumes plus an index and a multilingual glossary. The entire dictionary will cover general, nuclear, solid state, molecular, chemical, metal and vacuum physics, astronomy, geophysics, biophysics and related subjects. It is the first major dictionary of physics to appear since Glazebrook's *Dictionary of Applied Physics* (1922-23), but its scope is wider and its basis quite different. It aims at covering all branches of physics and such related subjects as mathematics, aerodynamics, hydraulics, metrology, radiation, physical and structural chemistry, crystallography and photography.

The work was compiled on a wide subject basis, but unlike Glazebrook there has been no attempt to separate the volumes into subjects; the arrangement is strictly alphabetical. The subjects were selected by a panel of some seventy consultant editors and the articles written by specialist contributors, thus aiming at comprehensive authoritative coverage, but necessarily resulting in some overlapping. The dictionary is intended primarily as a quick reference work and no articles are longer than 3000 words, the majority being much shorter. All articles are signed. Very few cross references are given, but it is stated that the index volume will give all reasonable variations of word order and reader approach as well as indicating the whereabouts of topics which are not themselves the subject of separate articles. This is certainly necessary and should be very useful as one has only to compare with, for example, the Van Nostrand *International Dictionary of Physics and Electronics* to see the possible variations in approach to the same topic. However, in the present volume the few cross references given do not appear to be very well chosen : for example, from Bragg Spectrometer the reader is also referred to Bragg Equation which is the immediately preceding article. There are bibliographies to about half of the articles, but their inclusion, length and value appears to vary with the hundreds of contributors.

The layout is clear and attractive and the publishers are to be congratulated on this attempt to fill an obvious gap ; but it is regretted that the price will put it out of the reach of all but the wealthiest of libraries.

VIBRATIONS FROM BLASTING ROCK

L. Don Leet

Publishers : Oxford University Press for Harvard University Press, Amen House, Warwick Square, London, E.C.4.

Price 27s. 6d.

EXPLOSIVES are normally used by the engineer as a means of excavating rock. Since their property of producing earth waves has never found any direct application except for seismic exploration, research into these vibrations in the ground has been limited. Sufficient work has however been done to show that it is only as a very rare occurrence that vibrations are generated of a sufficient intensity to cause damage. As a consultant, the author of this book has been himself responsible for much of this research, and he has prepared a volume which, with its adequate references, will serve as a good guide to those who seek a thorough understanding of the present known facts of vibrations from blasting.

As an introduction to the subject, Professor Leet has compiled a book which by its very nature can only skim over the surface of the matters dealt with. The chapters on " Explosives," " Rupture of Rocks " and " Elastic Wave Patterns," each cover fields of knowledge which are large and self-contained in themselves ; it is to the author's credit that he has been able to produce not only an easily understood introduction to them, but also has demonstrated their inter-dependence and relevance to his main theme.

The discussion of the elastic wave pattern set up in the earth by normal explosives, earthquakes, and atomic bombs, is the simplest and most readable ever to have appeared in print. The fact that the author is seismologist-in-charge at the Harvard Seismograph Station is sufficient to guarantee that accuracy has not been sacrificed for simplicity. The same chapter has a section on air-waves similarly produced and there we have the first hand results and conclusions of Dr. M. A. Cook who is an excellent authority on this particular aspect. Many of the problems associated with blasting are primarily caused by air-waves and although the material given here is not of direct practical application an understanding of the production and transmission of noise is essential in the use of explosives for quarrying.

The engineer, contractor, or quarry operator who reads this book to find out how to tackle a particular problem in the use of explosives will not find it very helpful. If a handy rule-of-thumb is needed to decide whether a particular blast will or will not cause disturbing vibrations then it is not possible to look up the answer here. (It is of course only fair to say that no other available textbook will give the answer either.) Instead there is a discussion on the various factors involved, and the limits of permissible vibration used by other authorities. Since Professor Leet is himself one of the foremost authorities in the world on the subject this unwillingness to state categorically what he himself considers to be safe limits when using explosives is at first sight disappointing. A second reading of the book however, will convince the student that the author is merely being true to the statement which he makes in his introductory chapter : " The exact manner in which all the factors are involved when rock is blasted depends upon the type of operation requiring blasting." An informed study of all the factors involved will in most cases of explosive usage lead to a satisfactory solution of the problems posed. As an outline of those factors and as a guide to further reading this book deserves a place on the bookshelves of the serious student.

CIRCUIT ANALYSIS

Elias M. Sabbagh.

Publisher : The Ronald Press Company, 15, East 26th Street, New York 10, N.Y.

Price 8.75 dollars.

THIS textbook for students of electrical engineering is based on a detailed study of the electric circuit, accompanied by the concepts of dieletric and magnetic circuits. Beginning with the electrical structure of matter and electric charge effects, the text proceeds to the electrostatic field and capacitance, and then to electric current and resistance. Further sections on the magnetic field, induction, and the magnetic circuit prepare the way for the study of circuit elements in Chapter 6. The fundamental laws of circuit theory are explained, and the book then continues to introduce the student in a logical sequence to the more sophisticated tools of circuit analysis such as transformation theories, complex algebra, the complex frequency method, and the Fourier series. Special techniques of analysis are discussed. The book provides the unusual combination in a work of its kind of fundamental electrical theory with subjects such as the signal flow diagram and equilibrium equations of magnetically coupled circuits. Its approach to the subject has been tested over a period of five years in the training of second-year students at Purdue University, and the idea behind the book may therefore be justly claimed to have proved its practical validity both in its own sphere and as a foundation for further studies.

Letters to the Editor

SAFETY IN CIVIL ENGINEERING

SIR,—I read with interest your article on page 353 of THE ENGINEER (September 1, 1961).

I cannot agree with your statement that it may be that the major value of the regulations will lie in deciding legally who is to blame when an accident occurs rather than in the direct prevention of accidents.

Before the Construction Regulations, 1961, were thought of, the only conditions which could apply on engineering sites was the Building (Safety, Health and Welfare) Regulations, 1948, and these specifically applied to superstructure work only.

It was impossible for the factory inspector to take any legal action against other contractors concerned with heavy foundation work, large concrete structures, boiler plant, or other heavy engineering plant, as these were outside the terms of reference of the Building Regulations.

The new Construction Regulations, 1961, now specifically involve all contractors on sites to comply with the Factory Acts, and will give the factory inspectors the necessary authority to take legal action against any offender who contravenes the basic requirements of the Factory Act.

My own experience on power station sites has proved that many contractors who are outside the regulations have openly flouted the common sense safety matters on sites, and it will be most interesting to see how they respond when the new Act becomes law.

G. G. THORNHILL,
Resident Engineer,
Willington Power Station

C.E.G.B. Midland Project Group,
Derby,
September 1, 1961.

NIGEL GRESLEY : LOCOMOTIVE ENGINEER

SIR,—Thank you for giving so much space to a review of "Nigel Gresley : Locomotive Engineer" (THE ENGINEER, August 25, page 321) at the time when your reviews must be severely restricted.

I am rather surprised that the photographic illustrations are not entirely to your reviewer's liking, because, as the introductory notes point out, they were chosen for reasons which might appeal to every engineer and student of locomotive design. Four of the line diagrams showing "unbuilt" designs have never been published before ; one is of considerable historic importance.

With due respect to your reviewer, I am not sure that the existence of the 90 m.p.h. speed limit was the over-riding reason for prior secrecy about "Mallard's" record attempt in July, 1938. Sir Nigel Gresley had obtained from the civil engineer a certificate confirming that the track was in safe condition for high-speed running. Armed with this Sir Nigel could surely arrange for once to make special tests at speeds in excess of the 90 m.p.h. limit.

I suggest that the vital reason for the secrecy was the generally known failure of the previous attempt to beat the L.M.S. record in 1937. Thus if "Mallard" also failed the second attempt need never become public knowledge. But the 1938 run was a brilliant success and, as I now know, the senior locomotive official on board, Mr. D. R. Edge, took the opportunity of the subsequent halt at Peterborough to telephone Sir Nigel Gresley and give him the great news.

The building of class "N.7" 0–6–2 tanks with round-topped boilers at Doncaster certainly perpetuated a tradition. But as the former Great Northern "plant" was not then equipped to construct Belpaire boilers it was cheaper to design a round-topped boiler than to buy special plant for one small order.

A somewhat similar position arose on the Southern Railway about the same time. Mr. R. E. L. Maunsell wanted to build the "Lord Nelsons" at Eastleigh but that works had never built Belpaire boilers so the "Nelsons'" boilers were perforce made at Ashford.

F. A. S. BROWN

Romford, Essex,
August 31, 1961.

CANALS IN THE ECONOMY

SIR,—In your issue of August 25, Mr. M. J. Macfarlane, after expressing surprise at finding himself in agreement with so responsible a journal as THE ENGINEER, purports to amplify your excellent recent leading article with some entirely misleading comments on the water supply policy of British Waterways.

We have consistently applied ourselves to water sales with the greatest commercial vigour, and our annual revenue from this source, now well over £500,000 and increasing year by year, is already three and a half times that received in 1948.

We work, however, under certain statutory and other limitations. Some water is taken free of charge under existing rights or supplied at less than a current commercial rate for the same reason. The vast bulk of the remainder (over 90 per cent on a recent calculation) is for cooling or similar purposes and returned to the waterway after use, the same water being used and re-used many times over. For this we inevitably apply a lower scale than for water actually consumed ; indeed, to demand more than a certain figure would in many instances drive the consumer to install a cooling tower and work in closed circuit.

Our charges are essentially a matter for negotiation between our customers and ourselves. Local circumstances have to be taken into account, not least the ability of the waterway to supply the quantity and quality required. The raw water we offer has often to be treated by the consumer before he can use it, and if he returns it to the waterway he has to comply with the stringent specifications of the River Boards. Many other considerations, both technical and commercial, are involved in assessing the value of raw water to industrial users and we retain a highly experienced consultant water engineer in support of our own specialists.

Any of your readers interested in informing themselves further of the complex issues involved and the existing limitations under which we work are invited to read chapter VIII of the report of the committee of enquiry into inland waterways (known as the Bowes Committee). This independent committee, which reported to the Minister of Transport in July, 1958, dealt at some length with water supply and, incidentally, cast no such aspersions as Mr. Macfarlane. They also made certain recommendations for the easement of our statutory position, but these have not so far been implemented by the Government.

V. H. TRIPP,
Principal Engineer

British Waterways,
London, N.W.1,
September 1, 1961.

THE TYNE TUNNEL

SIR,—The award of the main-bore contract brings the Tyne tunnel back into the news. In the spring of 1958 when it was last discussed in the press the writer made an abortive attempt to interest the authorities in an economical scheme for increasing the tunnel's capacity without increasing the bore and, therefore, the cost.

Now that the Mersey tunnel's four lanes have reached saturation point it is even more clear that this tunnel will be inadequate right from the start.

As Traffic Engineering (whatever it is) seems to be in the air, the writer thought he would like to give his scheme another airing !

The scheme is based on the simple fact that cars and light vans are, to-day, always less than 7ft in height. Given an internal diameter of 30ft it is easily seen that it is possible to fit in two carriageways with a height clearance of 15ft, plus a third carriageway beneath the deck of 10ft by 7ft in height. It is also clear that there is ample cross-sectional area left for fresh and foul air ducts.

As in the case of the Mersey tunnel this third lane would be used in either direction according to the traffic flow which, at peak periods, is invariably heavier in one direction than the other and also has a higher proportion of private cars.

Unlike the Mersey tunnel, which at peak periods has two high-speed lanes in one direction for private cars, the Tyne tunnel will be restricted in both directions by the speed of heavy lorries grinding up out of the tunnel up a one in thirty grade—which could be as low as 7 to 10 m.p.h. !

It is contended, therefore, that the Tyne tunnel will have very much less than half the peak capacity of the Mersey tunnel.

It is also suggested that owing to the higher speeds in the third lane the peak capacity of the tunnel would be increased by 50 per cent rather than 30 per cent.

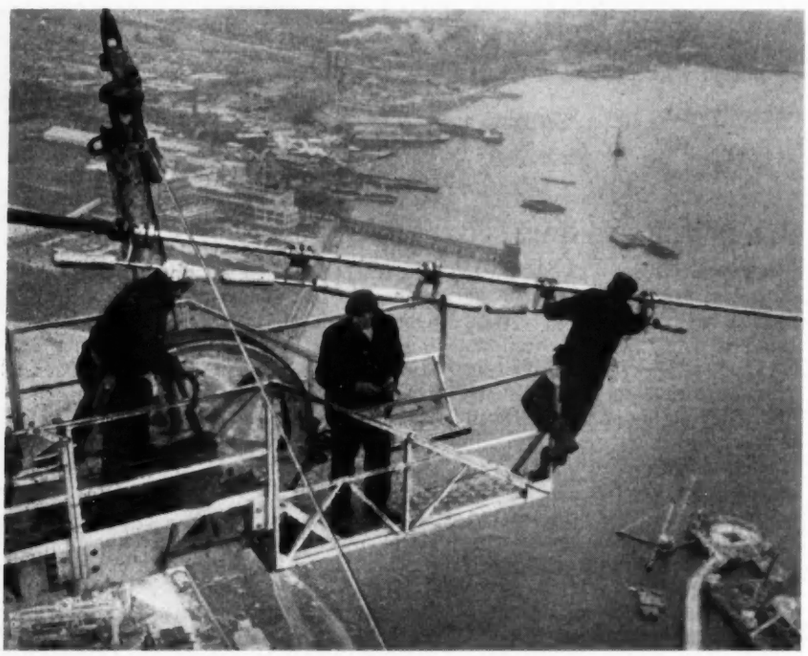
D. F. C. VOSPER

Llandovery,
Carms.,
September 2, 1961.

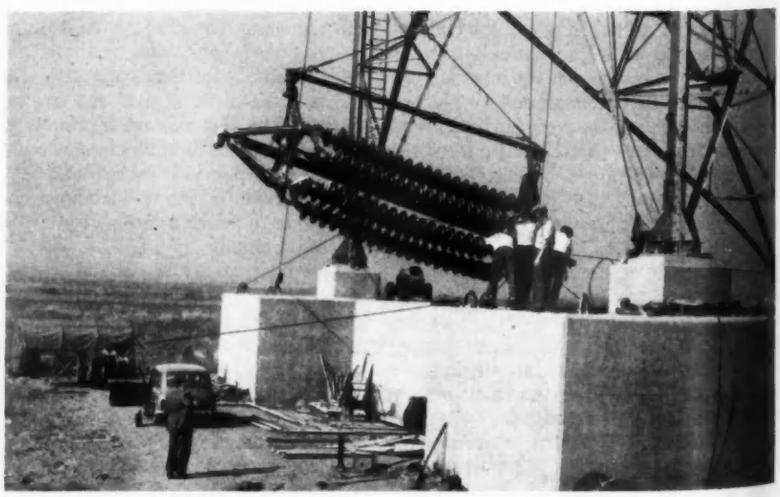
Thames Power Cable Crossing

Both circuits of the overhead power link crossing the River Thames between West Thurrock, Essex, and Swanscombe, Kent, have now been erected, and stringing of the earth wire is in hand. Some detail of the 630ft tower carrying the 4500ft crossing span, and of the 145ft anchor towers, were given in THE ENGINEER of January 13, 1961, page 49. The project is being carried out for the Central Electricity Generating Board by British Insulated Callender's Construction Company, Ltd. It extends the existing Supergrid north of the Thames, through the new 1000MW power station being built at West Thurrock, to connect with new lines to Canterbury, Lydd, the cross-Channel link, and the nuclear power station under construction at Dungeness. Commissioning of the crossing is expected in mid-October and will be a first step in reinforcing the 275kV system round London. It will also provide the C.E.G.B. with essential capacity for tests in connection with the cross-Channel cable, which should be commissioned about mid-December. The crossing is designed for eventual operation at 400kV.

For stringing the conductors, a haulage rope and a track rope were installed over carriages at the tops of all four towers, the haulage rope being connected to winches at the backs of the anchor towers. Each conductor was laid in small rubber-lined bobbins attached to 10ft suspension units running on trolleys on the track rope and clamped to the haulage rope. The end of each conductor was clamped to the haulage rope and pulled across the system under light tension, suspension units being fed on at 80ft intervals. The illustration ABOVE shows the haulage rope, conductor and suspension system during work at the south anchor tower. On reaching the anchor tower, tension was applied at both ends of the conductor to lift it clear of the suspenders. It was then lowered, by means of cradles at the crossing towers and by bridled tackles, down the faces of the anchor towers to its final position. The fitting of vibration dampers in the crossing span at the north tower is seen on the LEFT. The conductors consist of ninety 0·123in diameter preformed galvanised steel wires and a centre wire of 0·132in diameter. This steel core is surrounded by seventy-four 0·133in aluminium wires in two layers and a layer of thirty-six 0·0266 square inch (0·16in deep) wedge segmental wires. The latter are applied to present a smooth outer surface to reduce aerodynamic effects over the large spans. Overall diameter of the completed conductor is approximately 2·214in. The conductors were manufactured in continuous lengths of 7754ft at the Wire Mill Division, Prescot, of British Insulated Callender's Cables, Ltd., with the collaboration of Rylands Brothers, Ltd., Warrington.



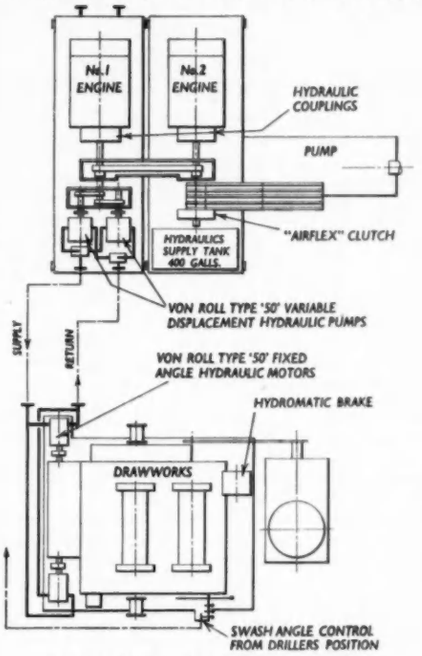
BELOW is seen a tension insulator assembly slung ready for lifting into position at the north anchor tower. There are six of these on each anchor tower, comprising eight strings of 20in by 12¾in diameter porcelain units in parallel. The assembly weighs 3¼ tons and is 24½ft long. On the crossing towers the suspension insulator assemblies comprise six strings of 20in by 14in diameter porcelain units in parallel, weighing nearly three tons and 21½ft in length. All these assemblies and their attachments to the towers were supplied by Bullers, Ltd., Stoke-on-Trent. Throughout the erection of the crossing contact has been maintained between the dispersed working points and a ground control station by means of v.h.f. radio, using Pye "Ranger" portable transmitter/receivers. Since the frequency allocated was shared with other services, directional aerials were fitted to the sets on the towers in order to confine transmissions to the crossing route area. When the earth wire has been strung, the track and haulage ropes will be lowered into the river and winched out. By arrangement with the Port of London Authority the river was closed briefly for the initial laying of these ropes on the river bed by barge, and similar closure will be required for their removal, the time allowed being four hours at low water.



Hydraulic Transmission for Oil Well Servicing

FOR several years the Drilling Branch of the B.P. Exploration Company, Ltd., has been interested in the development of hydraulic transmission for drilling equipment and two years ago sufficient progress had been made to permit of field testing the system. The experimental equipment consisted of a Ruston-Paxman 6 R.P.H. diesel engine as the power unit driving a swash plate pump and motor for transmitting a 200 h.p. drive into a C.150 mud pump. This preliminary experiment provided test figures and data indicating an achieved efficiency of 80 per cent and this was considered sufficiently encouraging to go forward with the design of a hydraulic drive for drawworks. The conclusion of the field tests coincided with a call for a flameproof, remotely powered drive for a marine well servicing unit which an associate company, Abu Dhabi Marine Areas, required for servicing off-shore wells in the Persian Gulf. To meet this requirement the Drilling Branch of the B.P. Exploration Company, Ltd., has developed a hydraulic drive to a National T.32.S drawworks which is at present engaged in drilling a new well near Retford. The work has been carried out in association with the Oil Well Engineering Company, Ltd., where the equipment was built and tested.

Our line drawing shows the overall arrangement of the drawworks and of the hydraulic drive, and our illustrations show the diesel engine driven hydraulic pumps with hose transmitting 400 h.p. and one of the two 200 h.p. continuous rating motors powering the drawworks. A mark 12 R.P.H. Ruston-Paxman diesel engine is the prime mover for the drawworks and is rated to develop 400 h.p. at 1250 r.p.m. It is fitted with a Fluidrive, size 29, SCR3 fluid coupling and drives two Von Roll, type 50, PEH variable displacement pumps at 950 r.p.m. through O.W.E.C.O. reduction chain drives. The pumps, of Swiss manufacture, are each rated at 200 continuous horsepower at 950 r.p.m., the maximum working pressure being 3500 lb per square inch. The O.W.E.C.O.-National T-32-S drawworks, without torque converter, has a rated input of 400 h.p. and is powered by two Von Roll, 50C, fixed angle motors, each rated at 200 continuous horsepower at 950 r.p.m. and mounted one at each end of the drawworks drive shaft. This arrangement of twin pumps and motors to form the hydraulic drive is intended to ensure that operations will be continued in the event of a failure of any single hydraulic unit. Pumps and motors are connected by a supply and a return line consisting of Hewitt-Robins Super-Monarch 3½in bore rotary hose having a working pressure of 5000 lb per square inch. The combined maximum displacement of the two pumps is 360 imperial gallons per minute, the fluid medium being "BP Energol H.L.80," of which about 250 gallons are required to fill the circuit. For storage of the hydraulic oil a 400 gallon supply



Layout of hydraulic drive for drawworks

tank has been provided ; the oil is generally operated at 160 deg. Fah. and to control the temperature there is an air-cooled radiator. To achieve maximum efficiency there is a small gear pump which boosts the pressure of the return oil.

The variable displacement pumps are intended to run at constant speed and the swash plate angle is controlled between 0 deg. and 25 deg. from the driller's position by means of a pneumatic system using air at 100 lb per square inch which is translated to servo hydraulic control at the pump, Keelavite Hydraulic control gear being fitted. Variation of the swash plate angle controls the volume and pressure of the hydraulic fluid and the revolutions per minute and torque of the motor. In the following table are set out hypothetical figures which do not take into account efficiencies, but which serve to illustrate the relationship between angle of pump, the torque of the motor and the pressure and volume in the system. The diesel power unit is rated at 200 h.p. at 1200 r.p.m. and 875 lb per foot torque, the pump is rated at 200 h.p. at 1200 r.p.m. and the motor at 200 h.p., all constant.

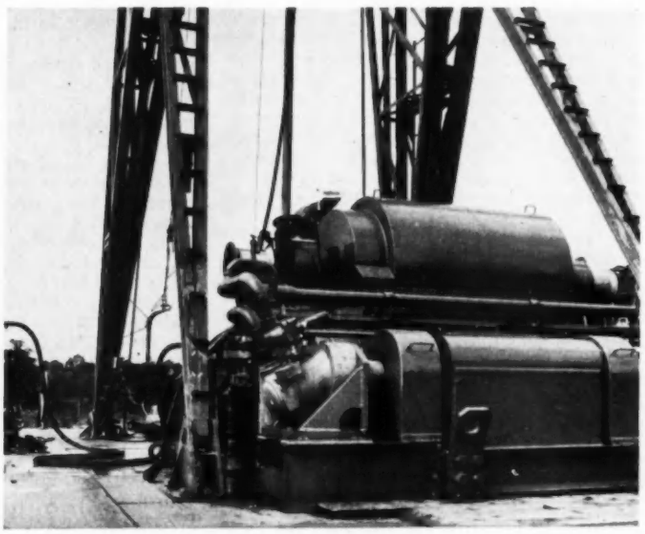
Hydraulic pump	Hydraulic system		Motor	
Angle deg.	Gallons per minute	Pressure, lb per square inch	R.p.m.	Torque lb/ft
25...	233	1230	1200	875
20...	188	1550	970	1095
15...	142	2000	730	1420
10...	95	3025	490	2140
8·30	82	3500	425	2480

At the site there is a Lee C. Moore 126ft jack knife mast built by O.W.E.C.O. under licence, and the hole being drilled is of 8⅝in diameter using some seventeen 36ft lengths of thickwall seamless tube drill collar piping and a drill string of 4½in diameter full hole pipe. Drilling is expected to continue to a depth of 4300ft.

The second 400 h.p. mark 12 R.P.H. Ruston-Paxman diesel engine drives a National C.350 7¾in by 18in mud pump at 54 strokes per minute through a conventional belt drive on the site, but is intended to drive a C.250 7¼in by 15in pump rated at 370 input horsepower at sixty-five strokes per minute at Abu Dhabi. The mud being used is a mixture of fresh-water and Bentonite having a specific gravity of 1·15 and is used as a jet to assist cutting. It both lubricates and cools the bits and lifts the cuttings to the surface where they are removed and the mud recirculated. On the site is a C.150 slush pump powered by a six-cylinder Paxman engine. Both the engine driving the hydraulic gear and that powering the mud pump are mounted side-by-side and may be compounded together. This arrangement not only allows flexibility of operation should there be an engine shut down, but makes available for pumping duties 800 h.p. minus that required for rotary table operations, while still maintaining control of the table speed through variation of the swash plate angle.

When servicing an offshore well the power units will be mounted on a work barge some 200ft distant from the drawworks, which are mounted on the helicopter deck of the wellhead platform. This is possible through the flexibility of the hydraulic drive which eliminates the need for a chain drive for the drawworks. Other advantages of the system are the reduction in noise and the possibility, when fully exploited, of cutting out one or two forward gears in the drawworks to effect a reduction in size and weight.

Diesel-engine-driven variable-angle hydraulic pump; part of drilling rig in background



Drawworks showing one of the two 200 h.p. hydraulic drive motors

SHORTER REPORTS

Report of the Geological Survey

SUBSTANTIAL progress in detailed geological mapping throughout Great Britain is described in the 1960 Report of the Geological Survey and Museum.* Some discoveries of economic significance were made during the year including coal seams in Oxfordshire, a bed of anhydrite in Northern Ireland, in both cases of workable thickness, and that the reserves of salt in Cheshire are double the previous estimates.

Coal in Oxfordshire.—The discovery of coal in a borehole at Apley Barn, Witney, about 10 miles from Oxford, was announced on July 20, 1961. It is the first coal to be found in Oxfordshire of a workable thickness. Coal measures were proved from 820ft to 3968ft and boring ceased on August 22 at a depth of 4942ft.†

This work was part of the Geological Survey's long-term programme of borehole drilling undertaken to obtain information on the relationship and composition of the deeper rocks in Southern England, and was the third borehole commissioned by the Survey between the River Severn and Oxford. Boring began in August, 1960, and the upper coal measures were first struck at 820ft. Between 1000ft and 1948ft nineteen thin coal seams were proved, and one 3ft thick at 1662ft. The next 655ft passed through were of variegated coloured mudstones, relatively barren of coal; the second coal group at the depth of 2603ft was found to contain 20ft of coal in eleven seams, three of them over 2ft 8in thick. Under this group was a Pennant-Sandstone-like group of rocks containing eight coal seams totalling 14ft including a 6ft 1in seam at 3633ft of which the bottom 4ft 11in are coal, and another 6ft 4in seam at 3786ft, of which the bottom 4ft 9in are coal.

Beneath this group lie conglomerates and sandstones of Devonian age to a depth of 4942ft; there are thus 3148ft of the upper coal measures in this borehole and no middle or lower coal measures. The National Coal Board is at present analysing the coals. Exploration of the extent of the coalfield by boreholes would be a lengthy procedure.

In the Witney Borehole, in rocks lying above the coal measures at a depth of 171ft, a representative of the Banbury iron ore bed was found which, unlike the 20ft thickness of this bed where it is worked north-west of Banbury, was only 1ft 9in thick, well below commercially workable thickness.

Salt Deposit in Cheshire.—The discovery and assessment of great additional resources of salt in Cheshire by the Survey's programme of boring has already been made known. The reserves of salt are now estimated as at least 400,000 million tons, twice the amount which could previously have been reasonably estimated. The cores of salt from these boreholes are being analysed in the laboratory of the Government chemist so that details may be made available for industry.

Gypsum in East Belfast.—The Geological Survey of Northern Ireland, set up in 1947, is now closely integrated with that of Great Britain.

A borehole was put down to a depth of 600ft at Avoniel, in east Belfast, to test the opinion, suggested by surface mapping and old records of boring for water, that anhydrite (an anhydrous form of gypsum) or gypsum itself might be present in commercial quantities. Drilling was completed early in 1960 and 16ft of massive anhydrite were proved between 365ft and 381ft depth below surface.

During the year the field unit completed mapping on the 6in to 1 mile scale of the Carrickfergus area and began resurveying the region, and the geophysical department, based in London, completed measurements of the regional variations in the force of gravity and of the intensity of natural magnetic forces (using an airborne magnetometer for the latter) over the whole of Northern Ireland. Variations in these forces reflect the nature and structure of the rocks at and below the surface. Reflection seismic methods were used to survey the sub-basalt rock.

* *Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for the Year* 1960. H.M. Stationery Office. Price 5s.

† A full account of this work is published in *Nature*.

Revised Metropolitan Line Services

FROM Monday next, September 11, Metropolitan Line trains of London Transport will terminate at Amersham instead of Aylesbury, and stations beyond Amersham will be served only by trains of the London Midland Region of British Railways. The London–Amersham services of London Transport will be worked by new A.60 stock multiple-unit trains (THE ENGINEER, June 9, 1961, page 955) replacing the locomotive-hauled trains of compartment stock which hitherto have been hauled by electric locomotives between London and Rickmansworth, and by steam locomotives between Rickmansworth, Amersham and Aylesbury. The A.60 stock will also form the peak-hour through services between London and Chesham. As a result of these service changes, the Metropolitan Line 1200 h.p. locomotives will be withdrawn from passenger service, but a few will be retained for non-passenger duties.

The above changes represent an interim stage in the modernisation programme for the Metropolitan Line, and follow the bringing into service of 2¾ miles of new double track from north of Harrow to just north of Northwood Hills. These tracks will be used by fast trains (British Railways and Metropolitan Line) not stopping at North Harrow, Pinner and Northwood Hills, which have no fast line platforms. Their stopping train service on the existing tracks will be augmented by extending certain trains, which formerly terminated at Harrow, to Northwood Hills, where a temporary reversing siding has been constructed. The two new tracks are being extended to Watford South Junction (3½ miles further), but will not be brought into use until station and bridge reconstruction and track layout alterations at the junction with the Watford branch, are completed next year.

Atmospheric Pollution Recorder

ATMOSPHERIC pollution is a subject of increasing importance as more areas are scheduled as smokeless zones, so that the positive control of smoke stack effluent is of immediate concern to heavy industry. To assist in such control Visco, Ltd., Stafford Road, Croydon has developed an isokinetic sampling apparatus which is designed to provide accurate and expeditious recording of dust, grit and fume emission from factory and other stacks. Marketed under the name V.I.S.A., representing Visco Isokinetic Sampling Apparatus, the equipment is a production version of an advanced system based on principles arising from investigations by the British Iron and Steel Research Association into atmospheric pollution. The apparatus is also expected to make a significant contribution to the efficiency of process control, essential because of present high fuel costs, by measuring flow rates and temperatures of gases, thus indicating the presence of air leaks which result in waste of heat and fuel.

V.I.S.A. consists of five linked units namely; sampling probe, filter unit, cooling coil, pump unit and instrument unit, and in addition a combined pitot tube and pyrometer is provided for measuring gas velocities and temperature. The sampling probe has an overall length of 5ft 6in and three nozzles of ⅜in, ½in, and ⅝in and is made of stainless steel. It faces directly into the stream of dusty gas and a sample is withdrawn isokinetically, the gas flowing into the nozzle in the same direction and at the same velocity as the undisturbed gas stream. The sample is then drawn through a filter of predetermined weight and cooled to ensure that corrosive liquids are not condensed in the sampling train. Samples can be taken quickly since the filter can be changed in as little as thirty seconds. The filtered and cooled gas sample is expelled by a gastight vane pump, equipped with a by-pass valve, through a gas flow rate indicator and an integrating meter. Then the filter is re-weighed, and the concentration obtained by dividing this mass by the volume of the gas sample. In order to sample isokinetically, the gas velocity and temperature in the stack are measured and indicated on the inclined gauge and millivoltmeter. Simple two-column tables relate this gauge reading to the isokinetic sampling rate, which is maintained by operating a by-pass valve. This method of flow rate control is made possible by placing the meters after the pump where gas pressures and temperatures are virtually constant.

The following are the weights of the various items in the equipment: probe and filter set case, 70 lb; cooler unit, 45 lb; pump, 60 lb; instrument unit case, 50 lb; and steel spider cable connecting set drum, which carries one 4ft, one 20ft and four 3ft gas-sample lines, 40 lb.

Railway into Road in Huntingdonshire

A LENGTH of abandoned railway line is to be used for a new "flyunder" junction as part of the modernisation of a further 1½ miles of the Great North Road (A.1) in Huntingdonshire. The Ministry of Transport has authorised Huntingdonshire County Council to place a contract with A. Monk and Co., Ltd., priced at £391,182, for carrying out this work, which will link earlier improvements to the south of Buckden and north of Buckden railway bridge.

On this length, the village of Buckden is astride the trunk road, which is narrow and winding, and there is a junction with A.141 where visibility is restricted. When the scheme is completed, all traffic from the south travelling to Huntingdon will turn left off the trunk road on to a link road beneath the old Buckden railway bridges and continue down the disused railway line, which will be converted into a 22ft carriageway. This link road, passing beneath the A.1, will join the A.141 at the site of Buckden Station Bridge, which is to be demolished. The scheme has been prepared by Huntingdonshire County Council's county surveyor, Mr. R. E. C. Dorling. It is expected that the new lengths of road will be open to traffic by the autumn of 1962.

Commonwealth Telephone Cable

H.M.T.S. "MONARCH" sailed on September 1 to lay the last 500 miles of the trans-Atlantic section of the Commonwealth telephone cable, and it is expected that the final splice will be made on about September 23 at a point some 50 miles from Hampden. The first length of the cable, which joins Oban in Scotland with Hampden in Newfoundland, was laid by the ship in April, from Oban to a point 750 miles west, and a second stretch of 750 miles was laid in June. On completion some 2100 nautical miles of submarine cable and eighty-six submerged repeaters will have been laid, including 1500 nautical miles of the new lightweight cable, the remainder in shallower waters being conventional armoured design the better to withstand damage due to shipping and abrasion.

Part of eight-bell, thirty-two base annealing installation

Bright Annealing Non-Ferrous Wire and Strip

BELL furnaces built by Efco Furnaces, Ltd. Queens Road, Weybridge, Surrey, have been used for bright annealing copper wire and strip at the works of Richard Johnson and Nephew, Ltd., Forge Lane, Manchester, for twenty-six years. At first the installation consisted of a single bell furnace and three bases, but the equipment has been augmented and a new building has been erected to house an Efco eight-bell, thirty-two-base installation. The centre of the building is used for the handling of charges and provision has been made for two parallel annealing lines on either side of the central area. Three of these lines are in use and the fourth is being built. Each line has eight furnace bases and two bell furnaces. A 2-ton charge, 54in high, in a 39in diameter baffle, is accommodated by each of the bases.

The furnaces operate at temperatures up to 550 deg. Cent., and are rated at 120kW. They are heated by nickel-chromium strip elements arranged in sinuous form round the chamber walls. Temperature control is automatic, with indicating and recording equipment, contactors fuses and pilot lights in separate floor mounted cubicles. Postioning of the bell as it is lowered is by means of locating posts, and the electrical connections are made automatically. Each base has an atmosphere circulating fan, and there is automatic audible warning if the fan should fail to operate. The protective atmosphere is produced from town's gas by five Efco exothermic generators, each having a capacity of 2000 cubic feet per hour, the gas being delivered to a ring main feeding the individual bases. Not more than four generators need to be used simultaneously to feed the complete installation.

London Transport Rail Stock Changes

WITHDRAWAL for scrapping of London Transport locomotive No. L.54, a 62-year old Peckett 0-6-0 saddle tank, has reduced the number of L.T. steam locomotives to twelve. No. L.53 Peckett saddle tank was withdrawn in 1960 and replaced by a former Western Region tank locomotive, but no replacement is being sought for No. 54. Four out of six of the oldest passenger vehicles owned by L.T.—the coaches of the former Chesham branch steam shuttle service—have been sold to the Bluebell Railway, Sussex, and a fifth—No. 519— is to be preserved at the British Transport Museum, Clapham, London, S.W.4. Three of the coaches—Nos. 512, 515 and 518—have been sold outright to the Bluebell Railway and one—No. 516—has been sold subject to the proviso that it shall not be disposed of without prior reference to the British Transport Commission. The sixth coach—No. 513—is likely to be broken up ; some of the parts may be used in the restoration of the coach going to Clapham.

A 1927 type driving motor car which has run nearly 1,500,000 miles on London Transport lines has been re-painted and restored to its original condition for preservation in the Science Museum, South Kensington, London, S.W.7. It is car No. 3327, and was built by the predecessors of the present Metropolitan-Cammell Carriage and Wagon Company, Ltd., being first put into service on the Piccadilly Line in July 1929. It was transferred to the Bakerloo Line in February 1931 and to the Central Line in March 1939, remaining in use there until recently, when it was displaced by the new L.T. aluminium-bodied stock. Like other Tube stock motor cars of its period, No. 3327 has an upswept frame at the driving end to give room for the driving bogie, which has larger wheels than the unpowered bogie at the other end. The driving wheels are 36in diameter and the unpowered bogie wheels are 32in diameter. Drive is from two nose-suspended axle-hung motors, each of 167 h.p. continuous rating, and the control equipment is housed in a compartment approximately 10ft 4in long, behind the driver's cab. With an overall length (over end panels) of 49ft 9 $\frac{7}{8}$in, maximum height from running rail of 9ft 6in, and width over body sides of 8ft 6in, the car weighs 29 tons 5$\frac{3}{4}$ cwt. in working order. Some small modifications have been made in order to allow certain working parts to be seen when the car is on display. It is not expected that the car will be on public view for two years, as it is to be displayed in a new gallery which is due for completion in the Autumn of 1963.

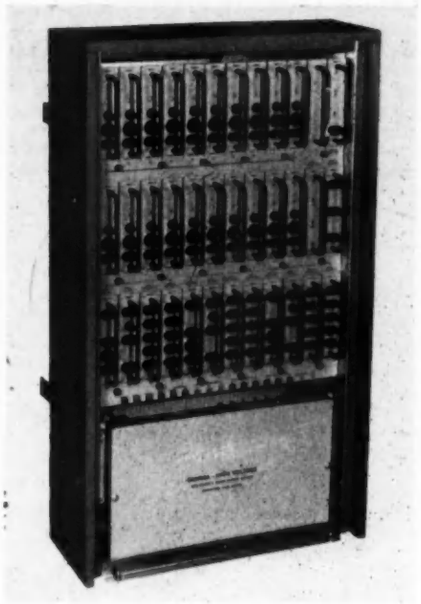
Convention on Materials Handling

THE Materials Handling Group of the Institution of Production Engineers, in conjunction with the Institute of Materials Handling are organising a convention on the theme " Profit by Handling." This convention will be held on November 3 and 4 next at the Connaught Rooms, Great Queen Street, London, W.C.2, and application for tickets should be made to the Institution of Production Engineers, 10, Chesterfield Street, London, W.1.

The papers presented for discussion will be arranged under two main headings—materials handling to and from the point of production ; and materials handling at the point of production. In the first classification there will be given the following papers : " Materials Handling in the Transport of Perishables," by Mr. R. Harvey ; " Rail Transport and Materials Handling," Mr. A. W. Davis ; " Cargo Handling by Mechanical Means," by Mr. G. W. Smith ; and " A New Covent Garden Market," by Mr. C. W. Glover. The papers on materials handling at the point of production include : " Materials Handling in the Post Office Supplies Department," by Mr. H. H. Simmons ; " Manufacture and Handling of Open-Top Containers," by Mr. C. H. Manners ; " Mass Production Handling," by Mr. M. Hulett ; and " Handling in the Manufacture of Flat Glass," by Mr. P. M. Denton.

Electronic Internal Telephone Exchange

QUANTITY production has been begun by Pye Telecommunications, Ltd., Newmarket Road, Cambridge, of a twenty-line electronic exchange for private internal telephones. As seen in the illustration, static switching is performed by plug-in cold cathode tube units with printed circuit wiring. Having no moving parts, and being impervious to dust and vibration, the exchange is suitable for locations where conditions



Twenty-line exchange with switching by cold cathode tubes for private internal telephone systems

are unfavourable for mechanical switching, such as mills and work sites. Telephone instruments of the latest G.P.O. approved design, made in lightweight " Diakon," are provided with the exchange. Since dialling speed is not critical as with mechanical selectors, the dials are adjusted to run at twice the normal speed. The instruments are normally in two-tone grey, but other colours and black are available on request. Wall-mounted telephones in the same range of colours can also be supplied.

[Reply Card No. 1163]

One-Man Autogyro

IT has been announced by British Executive and General Aviation, Ltd., that the aircraft projected by the group include the " Beagle "-Wallis WA116 autogyro. This machine was initiated as a private venture by Wing Commander K. H. Wallis on the basis of a Bensen " Gyrocopter " (see page 164, July 28 last) but by abandoning the objective of construction by amateurs it has been possible, it is claimed, to refine the design significantly ; in particular, it is claimed that it is not necessary either to track or to balance the (two) rotor blades. The redesigned machine is envisaged as having considerable utilitarian value with, for instance, the Royal Signals.

Since it is intended to secure patent protection on some features of the design, few details are at present available, but the machine has a McCulloch four-cylinder two-stroke of 70 h.p. It has been demonstrated to the Press, when it was seen to fly, hands and feet off, both at extremely low (almost hover) and reasonably high speeds. In the demonstration the engine was stopped at a height of about 100ft and the landing made " dead stick " at a very low forward speed. The speed range in level flight is quoted as 10–70 kt.

The machine has rotor diameter of 20ft 2in, a length of 9ft 6in, and a take-off weight of 580 lb.

SHORTER REPORTS *(Continued)*

Traversing Multi-Spot Welding Machine for Steel Strip

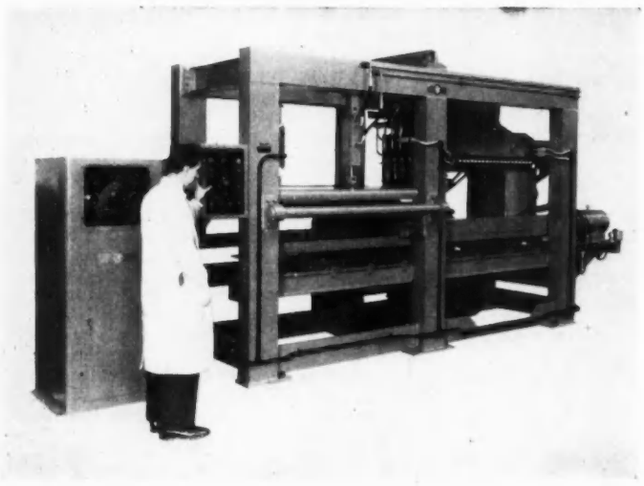
PARTICULARS have been received from Sciaky Electric Welding Machines, Ltd., Falmouth Road Trading Estate, Slough, Bucks., of an automatic traversing multi-spot welding machine developed for use in continuous strip mills, and other strip processing plant. This machine, illustrated below, serves to make a lap joint, by high-speed multi-spot welding, between the trailing edge of one coil in process and the leading edge of the following coil, to provide the required continuous strip for the processing line. The sequence of operations involved takes about four minutes or less, depending upon strip width. In this sequence the trailing edge is cropped square and inched into position and the leading edge of the new strip is also cropped before being fed up to lap over the trailing end of the strip in process. The strips are clamped and the welding operation then takes place, four spot welds being made in line and repeated across the width of the strip.

The machine is set across the line of the strip flow and it has a six column main frame with pass and side rollers for the strip at one end. Hydraulically operated clamps mounted in the frame are used to hold the strip during welding and their engagement automatically starts the welding cycle. A traversing " C " frame, which carries the eight welding heads, moves on a roller track along the length of the machine and when it is not in use, is stationed clear of the strip at the opposite side of the machine frame. For the spot welding operation this " C " frame is traversed by a lead screw driven by a 3 h.p. motor, a pneumatically operated clutch in the drive being disengaged to halt the frame for the welding cycles as it traverses across the width of the strip. The pitch of the welds can be varied by the setting of adjustable cams and when the electrode assemblies have retracted after making the final line of welds the " C " frame automatically returns to its station at the end of the machine. At this stage the hydraulic clamps are automatically disengaged to release the strip, which is then free to pass into the processing line.

The machine is served by two heavy-duty 100kVA transformers and has a nominal rating of 200kVA. In this equipment the secondaries are arranged in " push-pull," which is stated to avoid the inherent losses experienced with conventional spot welder secondary loops. Electronic control is provided by a thyratron timer, phase shift heat control and ignitron contactors which are housed in a separate cubicle. Push-button controls giving means of automatic or manual selection are situated in a convenient position for the machine operator.

This equipment is capable of handling strip up to 42in wide and weld thicknesses of 0·100in + 0·100in silicon steel strip, which can have the surface condition as received from the hot strip mill or cold reduction mill. Its automatic sequence is designed to carry out the spot welding operation with the minimum of delay, as whilst it is in progress the process line is dependent upon the material in a reservoir loop. If required the plant can be supplied with the maker's three-phase balanced load system, which operates at a power factor of not less than 0·85 giving a reduced power demand and a superior weld to the single-phase machine. The quality of the weld is such that the strip can be passed through annealing furnaces at 913 deg. Cent. and processing at strip tensions up to 1000 lb per square inch.

[Reply Card No. 1165]



Automatic traversing multi-spot welding machine for continuous steel strip processing lines

Ultrasonic Control System

TRANSISTORISED ultrasonic generators in conjunction with receivers and control units form the basis of an industrial control system announced by Tyer and Co., Ltd., Perram Works, Merrow Siding, Guildford, Surrey. Its applications are similar to those of photocell systems, but it is unaffected by fog, smoke or mist, and can be made immune from spurious operation by other sounds. Units are built on a modular system as used in other " Perram " industrial controls. Maximum beam length is 25ft. The equipment is supplied for operation either from 12V d.c. or from a 220V/250V mains supply. When beams are in close proximity to each other, they can be modulated with different frequencies. Suggested applications are level controls, conveyor controls, door operation, and for use in film processing laboratories where light and heat are inadmissible.

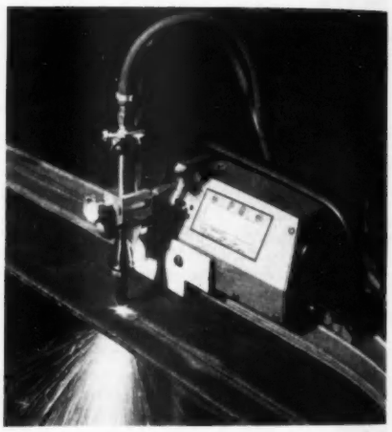
[Reply Card No. 1160]

Oxidation Processes in Chemical Manufacture

A SYMPOSIUM on Oxidation Processes in Chemical Manufacture is to be held by the London Section of the Society of Chemical Industry in the William Beveridge Hall, Senate House, University of London on September 28 and 29. Dr. H. M. Stanley will be in the chair at the opening session on Thursday, September 28 when two papers will be read ; " Liquid Phase Oxidation by Molecular Oxygen," by Dr. G. H. Twigg, and " Oxidation of Olefin's with Palladium Chloride Catalysts," by Dr. J. Smidt. In the afternoon, with Mr. N. A. Iliff in the chair the following three papers will be presented ; " Peracetic Acid—Its manufacture and Uses," by Mr. A. J. John and Dr. F. J. Weymouth, " Hydrogen Peroxide and other Peroxides in Chemical Manufacture," by Mr. T. D. Manly, and " Organic Oxidation by Metal Ions and Complexes," by Dr. R. G. R. Bacon. On the evening of Thursday a dinner will be held at the Connaught Rooms, Great Queen Street. Two papers, namely ; " The Controlled Gaseous Oxidation of Organic Compounds," by Dr. C. F. Cullis and " Recent Developments in Aromatics Oxidation," by Dr. R. Landau and Mr. R. W. Simon will be read on Friday morning under the chairmanship of Dr. J. W. Barrett. In the afternoon Mr. S. Muller will present a paper entitled " Recent Developments in the Oxidative Recovery of Chlorine from Hydrochloric Acid " and the Symposium will conclude with a commentary by Professor F. Morton the chairman of the closing session.

Small Portable Oxygen Cutting Machine

A PORTABLE lightweight oxygen cutting machine, known as the " Pug," now being marketed by the British Oxygen Company, Ltd., Bridgewater House, St. James's, London, S.W.1, is designed to cut and bevel steel up to 2in thick. The machine, illustrated below, weighs only 21 lb and it runs on light alloy track, which can be installed for the machine to make a straight cut of any length. Circles, from 3in to 45in in diameter, can be cut using an adjustable trammel attachment with the machine. The cutter can be moved in its holder through angles up to 45 deg. for bevelling and it can be adjusted vertically and laterally in the normal way.



Lightweight portable oxygen cutting machine which cuts and bevels steel plate up to 2in thick

Power for traversing the machine is supplied by a universal electric motor suitable for a.c. or d.c. at 220V/240V or 110V and with a maximum consumption of 80W. This drive gives a speed range of 7·3in to 36in per minute, and speed control is by rotary resistance with knob setting. The nozzle-mixing blowpipe is suitable for acetylene or propane as fuel gas.

[Reply Card No. 1166]

Durham Motorway

PROPOSALS to establish the route of a further 21 miles of the Durham motorway have been " published " by the Ministry of Transport. The proposed line of route has been surveyed by the Durham county surveyor. It connects with the proposed Darlington by-pass on the A.1 near Aycliffe, passes to the east of Aycliffe, to the west of Bradbury and Coxhoe, to the east of Durham and Great Lumley, and to the west of Lambton, and rejoins A.1 on the Birtley by-pass just north of Chester-le-Street.

In addition to the terminal junctions there will be connections with A.177 south of Bowburn and with A.690 at Carrville. The draft scheme and plans showing the proposed route will be open for inspection for three months during which time representations and objections may be made to the Minister.

Magnetic Filter for Fluids

A FILTER which combines the advantages of a magnet and filter mesh for removing contaminants from lubricants, cutting oils and emulsions and other coolants is made by Rapid Magnetic, Ltd., Lombard Street, Birmingham, 12. A permanent magnet in the filter retains the ferrous material and the mesh removes the remaining contaminants suspended in the liquid.

Magnetic filter for the removal of solid contaminants from the fluids in pipelines

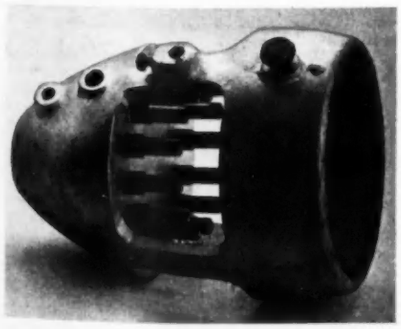
The general construction of a typical filter is shown in the cut-away section photograph we reproduce. Fluid enters the body of the filter at the centre and first passes through a strong magnetic field in the central compartment. This compartment is surrounded by a fine gauze filter through which the fluid passes to an annular chamber connected to the delivery line.

When it is required to clean the filter the cap is removed and the magnet and mesh assembly can then be taken out in one piece and washed clean. This cleaning operation can be quickly carried out without need for disturbing the main connections between the body of the filter and the pipe system. Filters of this design are available to comply with the requirements of a range of flows, viscosities and degrees of contamination.

[Reply Card No. 1167]

Tube-Firing Gas Burner for Immersion Heaters

A TUBE-FIRING gas burner for immersion heaters has been developed by W. H. Rowe and Son, Ltd., Quayside Road, Bitterne Manor, Southampton, with the co-operation of the Southern Gas Board, to provide an efficient and inexpensive method of tank heating in cases where immersion tubes can be installed. The burner, illustrated herewith, is fitted to a tube extension



Tube-firing gas burner for immersion heating of tanks

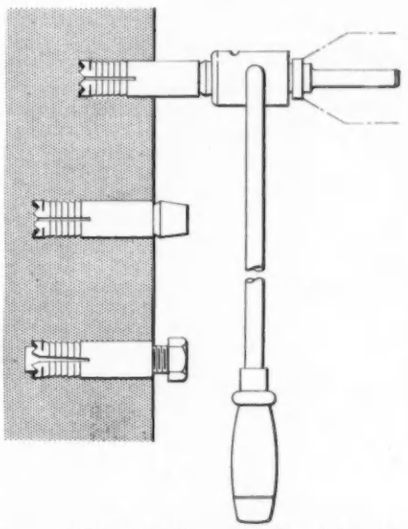
outside the tank and located by a set screw before the controls and gas supply are connected. Gas at mains pressure fires round the inner circumference of the tube to prevent short-circuiting of cold air. This 7¼in long overall burner is available in a number of sizes to fit tubes from 2in to 6in diameters and it is fitted with a pilot jet. The 2in diameter burner is equipped with five jets and the 6in diameter model with thirty-eight jets. A thermo-electric flame-protection device can be provided as well as means of thermostatic control.

[Reply Card No. 1168]

Self-Drilling Bolt Anchor

A SELF-DRIVING anchor for bolting equipment to concrete, floors, walls and ceilings has been introduced under the trade name " Anchorfast " by Andrew Fell and Co., Ltd., 17, Easton Street, High Wycombe, Bucks. The anchor is used to drill its own hole in the concrete, thus ensuring a close fit and eliminating need for special concrete drills. The design of the anchor and the sequence followed in its fitting can be seen in the diagram.

The combined anchor drill comprises a cylindrical body with a threaded bore and having



Sequence followed in fitting self-drilling bolt anchor into concrete wall

hardened cutting teeth round its end face. Longitudinal slots are machined up the toothed end of the body to a point beyond a series of inclined serrations, and at the opposite end the body is undercut to form a tapered head. For drilling the hole, using a power impact tool or a hand driver, the anchor is held by its head by a chuck through which it can be rotated as driving proceeds. When the anchor has been driven to the required depth—up to the undercut neck of the head—it is removed and the hole cleared.

A tapered plug is placed in the toothed end of the anchor which, still in its chuck, is replaced in the hole. By then hammering on the chuck shank the anchor is driven up the tapered plug and its inner end expanded to lock it firmly in the hole. The projecting head of the anchor can then be broken off at the neck by sideway movement of the chuck, the shank of which extends into the head bore as far as the neck.

Flush mounting anchors of this design are made in seven sizes for Whitworth bolts from ¼in to ⅜in. An anchor for use with hanger rods or for fastening timber to concrete is available in five sizes threaded from ¼in to ¾in Whitworth. For use with suspended ceilings and for fixing guy wires or lighting fixtures an anchor of $^{15}/_{32}$in outside diameter and having a $^{7}/_{32}$in diameter eye hole through its projecting shank is available.

[Reply Card No. 1169]

Continuous Discharge Rotary Vacuum Filter

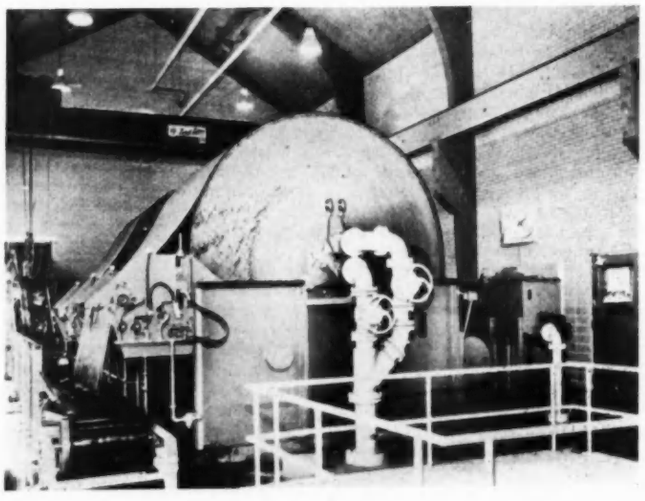
A ROTARY vacuum filter known as the " Eimco-Belt " and developed by the Eimco Corporation of America is now being manufactured by Eimco (Great Britain), Ltd. of Gateshead. This machine incorporates means for removing the filter belt from, and returning it to, the drum in the course of each revolution to give efficient discharge of the filter cake. No form of scraper blade or air blow is used for cleaning and the belt is washed before being returned to the drum. With this design a clean filter medium is continuously in use, giving sustained filtration efficiency and reducing the " downtime " involved for cleaning the belt. The absence of a scraper blade reduces wear on the filter belt. A zipper joint fitted in the belt is stated to enable a change of to be made in less than half an hour.

The filters are manufactured in standard sizes ranging from 18in diameter by 12in face to 14ft diameter by 16ft face, and are designed to operate continuously at 80/90 per cent peak capacity. The photograph reproduced in this page shows a double filter installation used with a conveyer belt for cake removal.

In each filter cycle the belt is removed from the drum and passed round a small diameter discharge roller. The sharp change in radius thus imparted causes the cake to break sharply away from the belt, and flexing of the belt extrudes cake from the weave. After cake discharge the belt passes round a wash roller and is cleaned on both sides by high pressure jets. These jets can be operated either continuously or intermittently, and the amount and force of the spray can be adjusted to meet operating conditions. Chemical washes may be introduced through the spray pipes to ensure complete cleaning.

Belt alignment is maintained automatically by movement of a special roller. Sensing microswitches detect belt movement and an electropneumatic mechanism capable of moving one half of the control roller in either direction along its axis corrects the position of the belt. The range of filter media available to meet filtering requirements includes a special corrosion resistant woven metal belt with an exceptionally long service life for use with coarse or fibrous solids.

[Reply Card No. 1170]

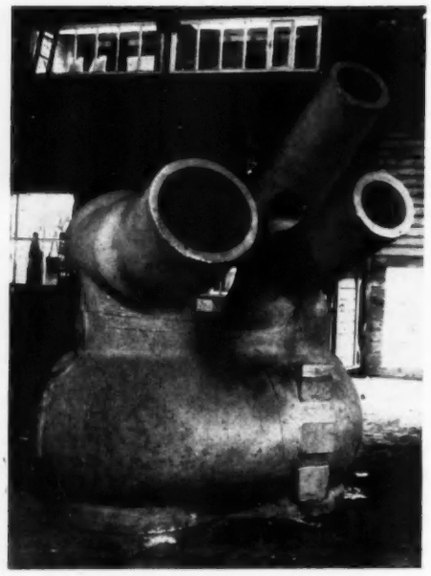


Double filter installation provided with a conveyor belt for the continuous removal of cake

SHORTER REPORTS *(Continued)*

Improved Casting Design by Co-operation

Two sets of intercept steam chests for West Thurrock 300MW turbine generator installation provide an interesting example of how machinery designers and component suppliers can co-operate to produce an improvement in design. The steam chests were ordered from Armstrong Whitworth (Metal Industries), Ltd., Western Road, Yarrow, by the Turbine Generator Division of Associated Electrical Industries,



Cast steel steam chest showing some of the design modifications adopted to improve the casting

Ltd., Manchester, 17, and the first of the sets has already been completed. They are chrome-molybdenum-vanadium steel castings, for operating at a pressure of 700 lb per square inch and a temperature of 1050 deg. Fah.

In the preliminary stages the foundry made three proposals for modifying the design with the object of ensuring a perfectly sound casting. These proposals were accepted by the machine designers. First, the ends of the branches were modified. As originally designed these ends had thickened sections to be drilled and tapped so that studs could be inserted for fixing blanking plates for hydraulic test. These local thickenings raised the problem of possible casting flaws due to irregular metal distribution. There was also a possibility of leakage round the studs and the likelihood of problems in welding to the next section of the turbine. As modified, the thickened ends were eliminated, the branch walls were tapered from 2¼in thick to 1½in thick in an outwards direction to assist directional cooling, and an extra 3in of length was given to the branch ends. For pressure testing a groove was machined on the outside of the extension, and a split cover was clamped in position to seal off the end. After testing the extra length of pipe end was machined off and the end machined to the required shape.

Secondly, a modification was made to the main body of the chest to allow the branch cores to be supported by a tie-bar instead of by chaplets which, it was considered, might affect the flow of molten metal in the mould, and might not fuse completely. As will be seen from the accompanying illustration the two branch ends (on the right) are at such an angle to each other and to the main body of the casting that a Y-shaped tie-bar could pass through both branches and through the main wall of the casting on the side opposite to the branch root, if a hole were provided in the main casting to accommodate the tie. This was done; a 6in diameter hole allowed the tail of the tie-bar to pass. After machining the hole will be sealed by a bolted-on cover plate.

Thirdly, the original provisions for integral casting of the brackets used for handling and mounting the chest was discarded, again because of the possibility of unsoundness due to unequal distribution of metal. In place of the integral brackets, simple pads were cast on. These will be machined, and the brackets will be bolted into position. Three of the pads can be seen on the lower right-hand part of the casting illustrated. The finish-cast chests were subjected to gamma radiography and dye penetrant crack detection as well as hydraulic test.

Valves and Tubes for Television

SEVERAL new valves and cathode-ray tubes for television receivers were demonstrated last week by Thorn-A.E.I. Valves and Tubes, Ltd., 155, Charing Cross Road, London, W.C.2., the company which has merged the cathode-ray tube and valve manufacturing interests of Associated Electrical Industries, Ltd., and Thorn Electrical Industries, Ltd. Among them was the 30C/17 variable-mu frequency changer, which enables automatic gain control to be applied to this stage of the receiver without affecting the oscillator frequency, so that valves without a variable-mu characteristic can be employed in the i.f. stages, resulting in extra gain. This is stated to be the only frequency-changer in the world which can be operated in a television tuner to provide a high conversion gain with good stability, and at the same time be gain-controlled by at least 100 : 1 from the a.g.c. line. The valve is of frame-grid construction in both sections, which are separately screened, enabling the pentode section to be used as an extra wideband i.f. stage on u.h.f. This application would arise in switchable receivers where on u.h.f. the tuner becomes an additional i.f. amplifier following a u.h.f. mixer.

Another introduction is the 30L/17 high-slope frame-grid double-triode cascode r.f. amplifier for television tuners, having a mutual conductance of 18-19mA/V. Basic stability, enabling gains of this order to be used, has been improved by attention to the internal screeening.

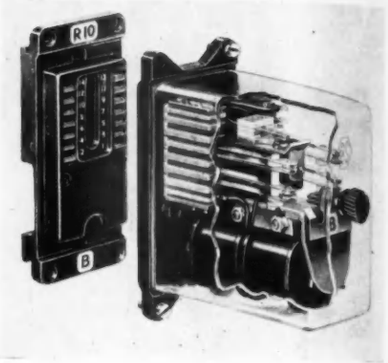
High-slope frame-grid beam tetrodes (6F28 and 30FL12) for video amplification were also shown, characterised by high available peak current enabling ample video drive to be provided for the cathode-ray tube with anode loads down to 4700 ohms, so that the tube can realise its full life capability. The valves are suitable for television sets designed for use on both 405-line and 625-line systems. A further high-slope valve which has been added to the range is the 30FL13 frame grid tetrode with general-purpose triode section, designed primarily for use in television synchronising pulse circuits. Demonstrations showed its ability to maintain line synchronism down to low video signal levels, and to reduce the effects of noise.

Two " shortened " cathode-ray tubes shown on this occasion were the CME1903 (19in) and CME2303 (23in), with neck lengths of 107mm and 110mm respectively. Both have guns of new design which are unaffected by their proximity to the back field due to the shorter length.

[Reply Card No. 1161]

Fleeting Contact Relay

To meet the needs of warning and control circuits where momentary contact action is needed to initiate a certain function, the Clifford and Snell D.2600 series relay (illustrated) incorporates a subsidiary relay which operates for about one-tenth of a second when the main relay is energised and released, or in one of those conditions only as may be required. The operating current for the subsidiary relay is induced in its coil by a change of current in the main coil. If the subsidiary contacts are required to operate only when the main relay is energised or released, but not in both circumstances, a rectifier inside the unit is connected so that induced current is blocked when its direction reflects the action of the main relay on which subsidiary relay operation is not required. Used in a warning circuit,



Relay with auxiliary contact for momentary make or break

for example, the auxiliary contacts might be required to close momentarily if the main contacts open, allowing a current pulse to reach a further relay or contactor which would latch in mechanically or electrically to operate a warning signal until the latter is acknowledged by pressing a button which unlatches the warning circuit relay.

The unit has the advantage over mercury switches that it can be used in any position, and in mobile applications such as on board ship. Sole distributor for this D2600F relay is D. Robinson and Co., Ltd., 5-7, Church Road, Richmond, Surrey. In common with all new D.2600 relays, the present model has " Mycalex " contact insulation and a new pattern base and socket. The socket pin numbers are moulded both on the back and front of the base to facilitate use of the sockets as test points when the relay is unplugged.

[Reply Card No. 1164]

Launches and Trial Trips

WEIRBANK, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for The Bank Line, Ltd., length between perpendiculars 450ft, breadth moulded 62ft, depth moulded to upper deck 38ft 6in, deadweight 12,030 tons (closed shelter deck) ; five holds, one 25-ton, four 10-ton and ten 5-ton derricks ; Doxford four-cylinder oil engine, 4800 b.h.p. Launch, June 29.

LARCHBANK, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., for The Bank Line, Ltd.; length between perpendiculars 450ft, breadth moulded 62ft, depth moulded to upper deck 38ft. 6in, deadweight 12,100 tons (closed shelter deck) ; five holds, one 25-ton, four 10-ton and ten 5-ton derricks ; Doxford opposed piston oil engine, four cylinders 700mm bore by 2320mm combined stroke, 4800 b.h.p. Trial, July 27.

EASTERN ROVER ; cargo ship ; built by Joseph L. Thompson and Sons, Ltd., for The Indo-China Steam Navigation Company, Ltd.; length between perpendiculars 380ft, breadth moulded 57ft, depth moulded to upper deck 35ft 3in, mean draught 23ft 5in, deadweight 7000 tons ; five main holds, served by 15-ton and 5-ton capacity derricks ; Hawthorn-Doxford opposed piston oil engine, four cylinders, 4600 b.h.p. at 117 r.p.m. Launch, July 28.

BRITISH PRESTIGE, oil tanker ; built at Barrow by Vickers-Armstrongs, Ltd., for the B.P. Tanker Company, Ltd.; length between perpendiculars 665ft, breadth moulded 95ft, depth moulded 51ft, deadweight 42,000 tons on 38ft 8in summer draught, sea speed 16 knots ; eleven groups of four oil compartments ; one set of double-reduction geared turbines, 16,000 service s.h.p. at 105 propeller r.p.m., 17,600 maximum s.h.p. at 108 r.p.m. Launch, July 28.

INDUSTRIAL NEWS

Trades Union Congress

In his presidential address to the Trades Union Congress at Portsmouth on Monday, Mr. E. J. Hill drew attention to the need for more factory inspectors. Nobody, he said, could be happy about the way the present Factories Acts were operating. More and more people were being injured in industry. More people were losing their lives at work. Many of these tragedies would never occur if the factory inspectors were able to keep a more watchful eye on what went on in the workshops. Mr. Hill went on to stress, however, that the inspectors themselves should not be blamed for this alarming situation. They were conscientious enough, he said, but there were less than 450 of them—with 250,000 workplaces to cover. The best they could do in the general run of workshops was to make an inspection once in every four years.

Commenting on the industrial health service and on an official report on the workshops of one industrial town, Mr. Hill said that medical supervision scarcely existed at all. To look after the health of 30,000 workers, he said, a few doctors spent a total of fifteen hours a week in the factories between them. These " scandalous facts " were all too familiar to every union official, he added, and could truthfully be repeated of scores of other towns up and down the country. But the bigger scandal, Mr. Hill suggested, was that since the facts were put on public record more than three years ago next to nothing had been done.

Mr. Hill went on to speak about the training of young people. Lively, intelligent young people were pouring out of the schools, he said, looking for a fair chance of a good start. And too few of them were finding it, in spite of all the efforts of the Industrial Training Council. Too many firms, he added, were dodging their responsibilities and battening on the good firms that had proper schemes of training and apprenticeship. The unions could not do much on their own to change things for the better, he said, the first move must come from the other side of industry.

Electrical Trades Union

On the opening day of the Trades Union Congress being held in Portsmouth this week, the Electrical Trades Union was formally expelled. Less than 500,000 votes were cast by delegations supporting the union, whose own vote brought the figure up to 735,000. Some 7,320,000 votes were cast supporting the T.U.C. General Council's recommendation for expulsion, giving a majority of 6,585,000.

Mr. George Woodcock, general secretary of the T.U.C., moving that the union be expelled, recalled that it was three years since the issue was first brought to the notice of congress. From late in 1957, he said, there had been in the Press serious criticisms of certain practices alleged to be part of the E.T.U's administration. There were charges of ballot rigging and of communist control or influence.

Details of a supplementary report on the affairs of the Electrical Trades Union, prepared by the General Council of the Trades Union Congress, were published in last week's issue of THE ENGINEER.

Exports

At the official opening of the new offices of Baker Perkins (Exports), Ltd., in Stanhope Gate, London, S.W.1, Mr. Harold Crowther, the chairman, made an appeal to the Government for a preferential bank rate for the export trade on long term credit sales. Mr. Crowther was introducing the Rt. Hon. F. J. Erroll, Minister of State, Board of Trade, who performed the opening ceremony. The Government, Mr. Crowther said, was penalising the home market and export market if research and development had to lag behind, due to enforced economies which might have to be introduced to counter some of the recent measures taken by the Government, particularly where credit and high interest rates were concerned. British manufacturers, he added, were now playing the role of the former banking institutions and having to provide long term credits if sales of capital equipment were to be effected. The Government had resisted appeals for incentives for exporting companies either by tax relief or subsidies, yet the German exporter benefited from his exports as compared with domestic sales by relief of the turn-over tax on his exports. The American exporter, who was having quite a success in Europe, had the help of lower interest rates, Mr. Crowther said, coupled with the assistance of the Import-Export Bank, and he was able to accept long term credit sales with great advantage over British competitors.

It was not possible to design essentially for the export market where capital equipment was concerned, Mr. Crowther said, the company could not indulge in technical risks at long distance. Without a solid home market with which to support its design and development of specialised machinery and gain experience, it would not have obtained the results overseas. Time and again it had proved the necessity of being technically advanced in the home market in order to exploit similar techniques overseas.

Mr. Erroll said in reply that he did not think it was the right occasion to indulge in a debate on Government policy. He would, however, consider carefully Mr. Crowther's remarks. He was amazed, he added, when told by different people of the difficulties that were hampering British exports, that Britain had any exports at all.

Management Problem of Designing for Productivity

An international survey of the management and function of design departments and drawing offices in the mechanical and electrical engineering industries is being carried out simultaneously for the Organisation for European Economic Co-operation in Austria, Belgium, France, West Germany, Italy, The Netherlands, Portugal, Sweden and the United Kingdom. The British report is being prepared, at the request of the Board of Trade, by the British Institute of Management in conjunction with the British Productivity Council. The results are to be forwarded to Paris where they will be studied and analysed.

Oil Consumption in United Kingdom

According to returns published by the Petroleum Information Bureau the total consumption of oil products in the United Kingdom, during the first six months of the year, reached 23,171,887 tons or 9·2 per cent more than in the same period of 1960. Fuel oil consumption increased by 9·7 per cent to 9,717,578 tons and gas/diesel oil deliveries advanced by 13·7 per cent to 2,009,621 tons. Motor spirit deliveries increased by 8 per cent to 3,927,694 tons and Derv fuel rose by 10·7 per cent to 1,386,022 tons, while consumption of aviation fuels increased from 804,497 tons in the first six months of 1960 to 1,006,818 tons in the corresponding period this year and reflected the larger demands of jet aircraft.

Post Office Overtime Ban

The Post Office Engineering Union claims that almost 100 per cent support was given by its members throughout the country to the four weeks' overtime ban which expired at midnight on September 2. Considerable arrears of work have accumulated, the union says, although union members have observed the principle of keeping public inconvenience to a minimum. Thus the arrears have been more on the installation than on the maintenance of equipment.

The ban was in protest against the refusal of the Post Office to negotiate a wage claim presented by the Post Office Engineering Union last November. The virtually universal support of this ban, even by many men in lower grades, to whom loss of overtime pay was a real sacrifice, indicates, the union says, the widespread bitterness of feeling against the Post Office.

The claim is to be heard by the Civil Service Arbitration Tribunal on September 12 and 13.

Apprenticeships

The National Coal Board has announced that in response to appeals from the Government and the Industrial Training Council, it is making special arrangements during the next three years to increase by 40 per cent the number of craft apprenticeships available to boys leaving school during the " bulge " period of 1961–63. These additional apprenticeships are required, the Board states, because of the large increases in mechanisation planned over the next few years. They will be open to suitable boys already working in the industry as well as to school-leavers. The Board is to offer more than 3400 apprenticeships in the years 1961, 1962 and 1963 as compared with some 2400 in 1960. It points out that the number of these opportunities will vary according to requirements in different parts of the country, but even more places will be made available if enough applicants come forward in places where they are specially needed.

The National Apprenticeships Scheme is designed to give boys the opportunity to become skilled mechanics and electricians at collieries, central workshops and other Board plants. The apprenticeship covers practical courses of instruction, planned practical experience, and technical education with day release.

PERSONAL AND BUSINESS

Appointments

THE RT. HON. EARL OF LISTOWEL has joined the board of F. C. Larkinson, Ltd.

MR. FRANK SHUTT has been appointed financial comptroller to Hawker Siddeley Industries, Ltd.

MR. P. E. LAZARUS has been appointed as principal private secretary to the Minister of Transport, the Rt. Hon. Ernest Marples.

B. B. CHEMICAL COMPANY, Ltd., announces the appointment of Dr. T. P. Hughes as joint assistant managing director of the company.

MR. ROBERT BUTLER, previously a director of Quasi-Arc, Ltd., has been appointed managing director of Eutectic Welding Alloys Company, Ltd.

MR. W. B. STRAITON has been appointed personnel officer to Powell Duffryn Engineering Company, Ltd., at the company's Cambrian Works, Maindy, Cardiff.

MR. C. R. RUSSELL, manager, export sales, M-O Valve Company, Ltd., has been appointed product planning adviser to the management of the company. He will retain his interest in sales while discharging his new responsibilities.

THE BRITISH BROADCASTING CORPORATION announces the appointment of Mr. H. C. J. Tarner, A.M.I.E.E., A.M.Brit.I.R.E., as engineer-in-charge, television (news), in succession to Mr. A. D. D. Strathairn, who has retired.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., states that Mr. A. C. Ehrenberg has been appointed manager and chief engineer of the Switchgear Testing Company, Ltd., Trafford Park, and that Mr. A. V. Sykes has been appointed secretary of the company.

THE MINISTRY OF AVIATION announces that Dr. G. G. Macfarlane, at present deputy director of the National Physical Laboratory of the Department of Scientific and Industrial Research, is being appointed director of the Royal Radar Establishment at Malvern. He will take up his new duties in the early part of 1962.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., a member of the Davy-Ashmore Group, announces the following new appointments: Mr. S. Baker, has been appointed general manager of the machinery division; Dr. R. B. Sims, M.I.Mech.E., is appointed director in charge of engineering; Mr. Alan Thomas is appointed secretary; and Mr. G. L. Carswell, C.A., is appointed assistant secretary.

VICKERS-ARMSTRONGS (ENGINEERS), Ltd., announces that with effect from October 1, 1961, Mr. R. F. W. Keay has been appointed an additional member of the Board and director of production engineering; Mr. P. D. Scott Maxwell, M.I.Mech.E., has been appointed a special director and deputy general manager, Barrow Works, and Mr. J. Hay, A.M.I.Mech.E., A.M.I.Prod.E., has been appointed a special director and works manager, Barrow Works.

THE GENERAL ELECTRIC COMPANY, Ltd., power plant division, announces that the former sales manager, Mr. F. L. Tombs, A.M.I.E.E., has been appointed manager, engineering services, with executive responsibilities for sales, tendering, contracts and operational services departments and for site resident engineers. Dr. D. Kalderon, A.M.I.Mech.E., formerly chief development engineer, has been appointed deputy chief engineer. Mr. W. G. Rhodes, M.I.Mar.E., A.M.Inst.F., is now manager, home sales. Mr. D. C. Thorpe is now manager, overseas sales.

VICKERS-ARMSTRONGS (SHIPBUILDERS), Ltd., announces that Mr. F. D. Stickland, commercial director, will retire from service with Vickers-Armstrongs (Shipbuilders), Ltd., on March 31, 1962, having then attained normal retirement age. In consequence Mr. W. A. Till, commercial manager, Vickers-Armstrongs (Engineers), Ltd., Barrow Works, will succeed Mr. Stickland, on the latter's retirement, as commercial director, Vickers-Armstrongs (Shipbuilders), Ltd., and will relinquish his present office on December 31, 1961. Mr. W. J. Scott will relinquish the office of commercial director, George Mann and Co., Ltd., and his seat on the board of that company, on September 30, 1961, and will become deputy commercial manager, Vickers-Armstrongs (Engineers), Ltd., Barrow Works, until he succeeds Mr. Till as special director and commercial manager on January 1, 1962. Mr. W. J. R. Cupples will succeed Mr. Scott as commercial director, George Mann and Co., Ltd., with effect from October 1, 1961, retaining his present appointments with Vickers-Armstrongs (Tractors), Ltd., Vickers-Armstrongs (Tractor Sales), Ltd., and Vickers-Armstrongs (Tractors), Canada, Ltd.

THE GOODYEAR TYRE AND RUBBER COMPANY (GREAT BRITAIN), Ltd., announces the appointment of Mr. Peter Gomm as manager, public relations, a newly created post. New public relations consultants appointed to the company are Voice and Vision, Ltd.

INTERNATIONAL HARVESTER COMPANY OF GREAT BRITAIN, Ltd., announces the appointment of Mr. James R. Boerger as director of manufacturing in succession to Mr. G. Gordon Davis, who has returned to the United States. Mr. Boerger has been elected a member of the board of directors.

Business Announcements

THE VISCO ENGINEERING COMPANY, Ltd., incorporated in 1921, changed its name on August 10, 1961, to Visco, Ltd.

E. BOYDELL AND CO., Ltd., Manchester, has appointed H. W. Lees and Son, Linden, Kill Lane, Foxrock, Co. Dublin, as its sole distributor in Eire.

AUTOMATIC CONTROL ENGINEERING, Ltd., has opened its new Northern Area Design Office at 15, Bloom Street, Manchester, 1 (telephone, Central 1462-3).

THE NIG MANUFACTURING COMPANY, Ltd., has opened a branch office, show-room and stock-room at 916-918, Stratford Road, Sparkhill, Birmingham (telephone, Springfield 1455).

TUNG-SOL ELECTRIC Inc., New Jersey, U.S.A., has appointed Walmore Electronics, Ltd., 11-15, Betterton Street, Drury Lane, London, W.C.2, as its distributor in the United Kingdom.

THE GEORGE COHEN 600 GROUP, Ltd., announces the retirement of Mr. C. E. G. Nye from the board of George Cohen, Sons and Co., Ltd. Mr. Nye has been with the company for forty years.

MR. T. H. ISHERWOOD, joint managing director of the Bromford Iron and Steel Company, Ltd., West Bromwich, for the past ten years, has tendered his resignation from the board of directors.

ASSOCIATED COMMERCIAL VEHICLES, Ltd., announces that its main subsidiary company, A.E.C., Ltd., subject to Argentine Government approval, has entered into an agreement with Sian Di Tella Automotores S.A. to manufacture A.E.C. passenger and goods vehicles under licence in the Argentine.

KINNIS AND BROWN, Ltd., 62, New Broad Street, London, E.C.2, announces its appointment as sole concessionaire and main distributor for Aqua-Clear, the non-toxic corrosion and scale inhibitor. It has appointed T. B. Bilton and Sons, Ltd., Bird Street, North Shields, as distributor for the North East England area.

WILLIAMS AND WILLIAMS, Ltd., announces that Mr. J. F. Wilkinson has been appointed new general manager of Roften Works, Hooton, in succession to Mr. E. B. T. Wright, who has left to take up an appointment in the Far East. Mr. L. A. L. Brown has been appointed to the position of deputy general manager (technical) at Roften.

THE ENGLISH ELECTRIC COMPANY, Ltd., is extending the scope of activity of its mining division, and from September 1 it will be known as the mining and materials handling division. It will be responsible for comprehensive schemes involving the application of electrical equipment to bulk and raw materials handling and processing.

THE U.K. ATOMIC ENERGY AUTHORITY has agreed to release Mr. P. T. Fletcher, M.I.Mech.E., M.I.C.E., M.I.E.E. (previously deputy managing director, development and engineering group at Risley and, since April, special adviser to the member for reactors) to take up the appointment, as from October 1, 1961, of director responsible to the board of the United Power Company, Ltd., for construction and supply. United Power Company, Ltd., is a company recently formed to unite the nuclear engineering activities of Atomic Power Constructions, Ltd., and the G.E.C. and Simon-Carves Atomic Energy Group.

ACHESON INDUSTRIES (EUROPE), Ltd., and CABOT CARBON, Ltd., Stanlow, Ellesmere Port, Cheshire, have concluded a sale-purchase agreement under the terms of which Cabot Carbon, Ltd., will purchase the business and manufacturing facilities of the Dispersed Pigments Division of Acheson Industries (Europe), Ltd., at Dukinfield, Cheshire. The transaction is part of a larger agreement whereby Cabot Corporation, of Boston, Massachusetts, acquire the business and manufacturing facilities of the Acheson Dispersed Pigments Company, Philadelphia, and its subsidiaries and affiliates. It is expected that the transactions will be completed during October, 1961.

MR. HECTOR D. WALKER has retired from the board of Constructors John Brown, Ltd. He will continue to be associated with the company as a consultant and as a director of the C.J.B. subsidiary companies Automatic Control Engineering, Ltd., and Corrosion and Welding, Ltd.

THE INDEPENDENT TELEVISION AUTHORITY has appointed Mr. D. H. Rennie as engineer-in-charge, and Mr. G. I. Wilson as assistant engineer-in-charge of its transmitter at Durris, near Aberdeen. It has also appointed Mr. P. G. James as engineer-in-charge, and Mr. G. Askey as assistant engineer-in-charge of its transmitter at Mounteagle, on the Black Isle.

NEW HOLLAND MACHINE COMPANY, Ltd., has opened a new factory at Gatehouse Road, Aylesbury, Bucks., where it will manufacture its complete range of agricultural machinery for grassland farming. On a 10-acre site, the factory covers 62,000 square feet, of which 48,000 square feet will be devoted to manufacture. The new factory was built by John Laing and Son, Ltd., and was opened by The Rt. Hon. The Earl De La Warr. The Company's factory in Southern Road, Aylesbury, where much of the paint spraying is done, is to be kept going. The service and spare parts departments of the company will be centralised in this factory also, when they are moved from Bonds Mill, Stonehouse, Gloucestershire, in early September.

Contracts

AUTOMATIC CONTROL ENGINEERING, Ltd., has been awarded a contract by the Ministry of Works for mechanical and electrical services in connection with the instrumentation of No. 3 test cell, and other units, at the National Gas Turbine Establishment, Pyestock, Hampshire (See page 927, June 3 1960). This contract is on a day-work basis, is worth approximately £70,000, and runs for one year from May, 1961.

CLUGSTON CIVIL ENGINEERING, Ltd., has been awarded a contract, at a figure of £357,302, for the construction of a by-pass round the Lincolnshire village of Laceby, on the Sheffield–Grimsby trunk road (A18). Work should be completed by November, 1962, and will provide dual 24ft carriageways in place of an inadequate single carriageway. The improvement scheme has been designed by Mr. C. K. Tallack, county surveyor of Lindsey.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has been awarded contracts worth £214,000 by the British Transport Commission for traction and signalling power cables in the London areas of the London Midland and the Southern Regions, British Railways. One of the contracts, valued at £113,000, is in connection with electrification renewals between Kilburn and Camden, and between Camden and Broad Street, London Midland Region. It includes the supply and installation of 36,000 yards of 11kV, three-core, solid cable, together with certain quantities of lower-voltage and telephone cable; construction of the cable route; and the dismantling and recovery of old cables and route materials. In the Southern Region, signalling power cables are to be supplied and installed on about 20 track-miles of the suburban lines from Charing Cross, Victoria and Cannon Street stations. Approximately 40,000 yards of 3·3kV and lower-voltage corrugated aluminium-sheathed solid cables, and approximately 24,000 yards of pilot supervisory cable, plus associated route works, are involved in a contract worth £101,000. The work on both contracts will be carried out by A.E.I. Construction (Cables and Lines) Division.

Miscellaneous

CORRECTION.—We are informed by British Steam Specialties, Ltd., that it does not make the "Airpel" filter as stated in our issue of August 18 last ("Liquid Filters," page 281). These filters are made by Airpel, Ltd., Lower Road, Chalfont St. Peter, Bucks.

ADHESIVE-COATED COPPER FOIL.—A range of electro-deposited copper foil of printed circuit grade is announced by Fothergill and Harvey, Ltd., Sladen Wood Mill, Littleborough, Lancs. The foil is coated with a dry thermosetting adhesive film which causes the copper to be bonded to the resin-impregnated core stock in the same process as that which bonds together the individual plies forming the base laminate. Three weights, 1, 2 and 3 oz. per square foot, are available. The manufacturer is prepared to advise on the press cycle best suited to the properties of the adhesive film and of the laminates with which it is used in the production of printed circuit boards.

CONTINENTAL AFFAIRS

by Our Continental Editor

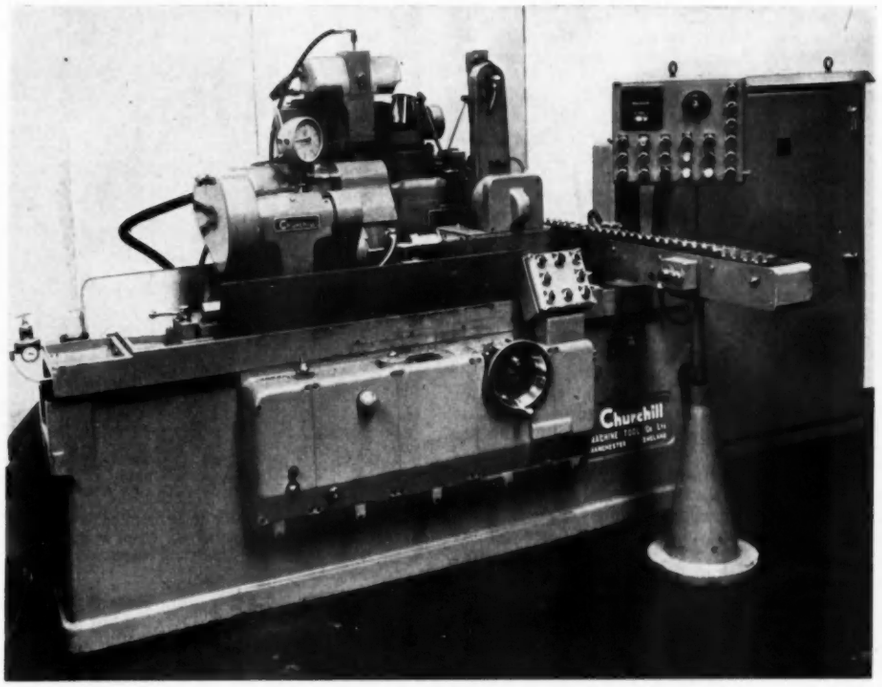
European Machine Tool Exhibition

No. I

THE seventh European Machine Tool Exhibition was opened at Brussels on Sunday, September 3, and occupies the whole of the "Centenaire Palaces" covering an area of over 25 acres. Exhibitors from ten countries are estimated to have on their stands a total of 15,000 tons of equipment, a majority of which is shown in operation. As in previous exhibitions in this series, in addition to machine tools of all kinds, there is a widely representative display of accessories, attachments, instruments, measuring and testing equipment, controls, drives, and other equipment. The German machine tool industry is, once again, the most fully represented with 280 firms showing. Other participating countries, and their representation, are as follows: Austria, 12; Belgium, 38; Denmark, 5; France, 153; Great Britain, 68; Holland, 20; Italy, 90; Sweden, 16 and Switzerland, 85.

For this first article on the exhibition we have selected the products of some of the British firms for brief description. Amongst the largest of the exhibits from this country is a planing machine of 6ft by 6ft by 20ft capacity made by Kendall and Gent, Ltd., Gorton, Manchester. Each of the three heads on this machine is a self contained unit driven by a 30 h.p. motor. This individual drive gives flexibility in operation by permitting each individual milling head to run at the speed most suited to its own particular type and size of cutter irrespective of the speed of any other head. The individual motor drive permits a short rigid transmission, suiting the heads for the use of both carbide and high speed steel cutters.

Each spindle has sixteen speeds from 12 to 800 r.p.m., selection of the required speed being by lever control and handwheel in conjunction with a direct-reading indicator dial. The vertical milling head spindle is also provided with stepless boring feeds ranging from $\frac{1}{4}$in to 12in per minute. Spindle retraction and means of incremental feed allows the operator to control the locking, retraction and resetting of the cutter spindles from a centralised control station. All three milling heads, and the table traverse, are provided with electronically controlled steplessly variable feeds from $1\frac{1}{2}$in to 45in per minute. Change of feed rate is by a single control knob which can be operated whilst the machine is in operation; and the rate in use is indicated on a large diameter tachometer dial.



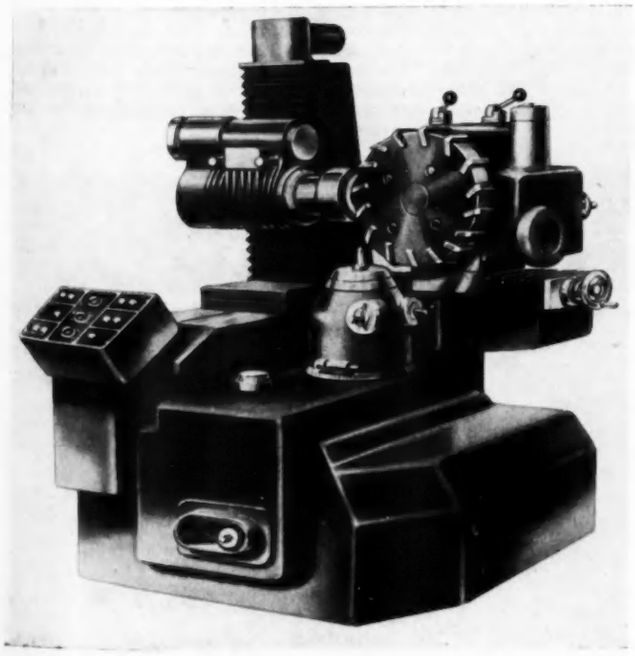


Fig. 1 (Above)—Fully automatic plain cylindrical grinding machine fitted with a swinging arm component loading and unloading device—Churchill

Fig. 2 (Left) — Automatic grinding machine for inserted blade milling cutters up to 30in diameter. Its grinding slide has a stroke of 5in and it has four rates of infeed from 0·0002 to 0·0008in per stroke — Kendall and Gent

A new automatic face-milling cutter grinding machine of Kendall and Gent, Ltd., is designed to handle carbide or high speed steel inserted blade milling cutters from 3in to 30in diameter. On this machine (Fig. 2), the main cutting edge of the cutters can be merged to the dish edge by one or more chamfers or by a radius—in the latter case the whole contour of the blade, including the radius, can be ground in a single operation. It can also be used for cylindrical rough grinding the blades by a simple rotary movement.

Automatic cycles for three different grinding methods are incorporated in the machine and are selected from a control switch mounted on the operator's push-button station. In each method the preset cycle of grinding repeats automatically until all blades in the cutter have been ground; after one full revolution of the cutter the machine stops automatically. No dividing plates are necessary on this machine since the blades themselves determine the required position by indexing against a flexible steel blade rest. The grinding slide, with a stroke of 5in, can make from four to eighty strokes a minute, and it has four infeed steps of 0·0002in to 0·0008in per stroke.

Two precision production machines, a plain cylindrical grinder and a fully automatic sizing internal and face grinder, have been selected by the Churchill Machine Tool Company, Ltd.,

CONTINENTAL AFFAIRS *(Continued)*

Broadheath, Manchester, for demonstration purposes. A model "BW" plain cylindrical grinding machine in addition to being arranged for the automatic loading of components has a controlled cycle which provides for the automatic grinding of the component, gauging to size and automatic ejection, there being also provision for automatic wheel-truing and compensation for wheel wear. The machine, which is arranged for plunge cut grinding, can be fitted with wheels up to 24in diameter by 6in wide or 24in diameter by 4in wide. It can be seen in Fig. 1 fitted with a swinging arm loader such as is applied in a linked line system.

The movement of the arm in swinging from "pick-up" to "load" position and of the jaws for gripping and releasing the component in these positions is actuated hydraulically. There is also a third movement of the whole device in a longitudinal direction, operating in conjunction with other mechanisms within the machine, for automatically advancing and retracting the tailstock centre.

The conveyor along which the components approach the machine is arranged to pass at right angles across the tailstock end of the machine, an arrangement that has the advantage of leaving the front of the machine clear for setting-up and maintenance purposes. After grinding, the components are returned to the conveyor which moves in stepped sequence.

In addition to an automatic crankpin grinding machine and an automatic camshaft grinding machine of American design and British manufacture Landis Lund, Ltd., Keighley, is showing the Gardner double spindle disc grinder. This disc grinder has a capacity for work up to 4in wide and 30in diameter and it is exhibited grinding side faces of bearing rings. The machine, of through-feed design, incorporates an automatic gauging and size control whereby components are checked following the grinding operation and any required adjustments are automatically made to the wheel heads.

Amongst the grinding machines of A. A. Jones and Shipman, Ltd., Leicester, is a new 6in by 18in surface grinder and a honing machine. The surface grinding machine has a table arranged for both hydraulic and hand operation with a maximum longitudinal traverse of 19½in. Under hydraulic power the table speed is steplessly variable from 5in to 72ft per minute including reversals. The maximum cross traverse of the table is 6¾in and hand and automatic operation are also provided for this motion. The feed range when hydraulically operated is variable from 0·007in to 0·154in per stroke and the rate is adjustable whilst the machine is working. Micrometer adjustment is by a fine feed knob graduated in 0·0001in divisions. The wheelhead has a vertical traverse of 11in and power rise and fall under lever control is fitted. Micrometer vertical adjustment of the head is in increments of 0·00005in.

The honing machine (Fig. 3) has been specifically designed for microhoning bores which are comparatively small in relation to their lengths. Its spindle unit is housed in a hydraulically operated reciprocating quill, the drive being from a 2 h.p. motor and providing steplessly variable speeds from 175 to 940 r.p.m. The reciprocating speed is variable up to 65 surface feet per minute.

A constant and positive rate of feed is applied by a "Microdial" and power for the feed cylinder is supplied by a separate hydraulic system. The positive stone expansion rate is obtained by a mechanical linkage from the feed cylinder to the adjusting head. Automatic tool collapse coincides with the maximum stock to be removed on diameter and compensation for stone wear is automatic. Initial tool expansion ensures that at the start of the honing cycle the stones are automatically expanded instantly to nominal bore size.

Automatic sizing is by a gauge ring having an internal diameter the required size and which is actuated by the tool to terminate the cycle when the bore reaches the ring size. Repeat diametrical accuracies are stated to be of the order of 0·0003in or less.

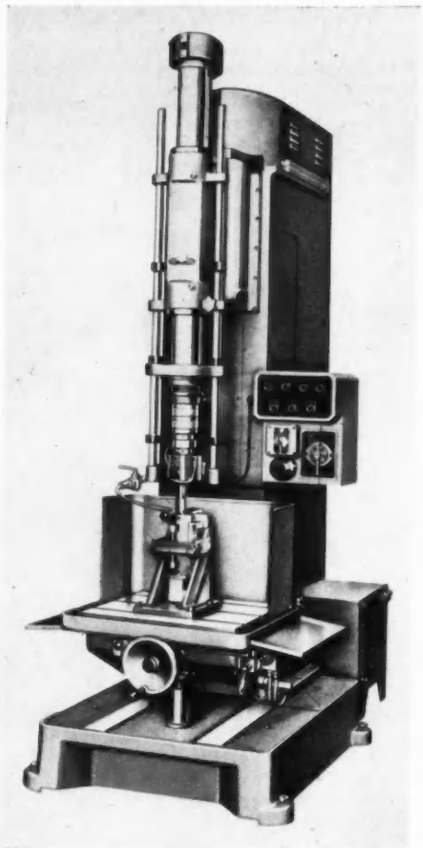


Fig. 3—Honing machine with a longitudinal traverse of 19½in for bores comparatively small in relation to their length—Jones and Shipman

With one of the well-known "S"-type "Optimetric" high-speed tool room boring machines and a facing chuck model horizontal surfacing and boring machine H. W. Kearns and Co., Ltd., Broadheath, is exhibiting for the first time its model "721P" tool room boring, milling, drilling and tapping machine. In this machine a new design of facing chuck is carried on a forged steel sleeve running in two long parallel bearings, one of which is placed well forward to reduce overhang of the cutting tool to a minimum.

The spindle of the machine can be revolved independently or with the facing chuck. A tool holding device with hydraulic release is operated by a rotary switch in the main control pendant of the machine. To ensure constant accuracy when holding the No. 40 non-stick mandrels in the spindle nose, the central draw bar is pulled into position by a powerful spring housed at the end of the main spindle; no danger can arise from hydraulic failure. To release tooling, the spring is overcome by applying hydraulic pressure to a cylinder attached at the end of the spindle. A bayonet catch enables rapid tool replacement, and electrical interlocks ensure that the spindle cannot rotate with tooling in a released position.

Representative of the ram type horizontal milling and boring machine of the Asquith Machine Tool Corporation, Ltd., is a 6in machine on the stand of Drummond-Asquith, Ltd., Birmingham. This firm is also showing a British built 2AC Warner Swasey single-spindle chucking automatic which swings up to 12in over the cross slide. In this machine (Fig. 4) the workpiece is held in a rotating chuck whilst front and rear cross slides feed cutting tools at 90 deg. to the spindle centre line and a five-station main tool slide feeds tools parallel to the spindle axis. The pentagon turret and cross slides can function in various combinations with each other. These and all other machine functions, relating to component requirements (speeds, feeds, cutting stroke lengths, dwell, &c.) are controlled electrically and are selected automatically by adjustable trips. A pentagonal control drum equipped with adjustable trips selects for the individual tools their feeds, speeds and length of cutting stroke. Permanent cams are used for controlling both the turret and cross slides and the two mechanisms eliminate all need for cam changing.

The gear hobbing equipment shown by David Brown Industries, Ltd., Manchester, includes a "UPH30" precision gear hobber of about 30in capacity which incorporates electric control equipment for checking and automatically controlling errors in table drive. It has a fully automatic cycle controlled by a single push button and can be manually operated for generating small batches of spur and helical gears, sprockets and spline shafts. A universal hob slide can be fitted to the machine to generate worm wheels by the tangential feed method.

A new machine developed by this firm is a hob sharpener (Fig. 5) which takes hobs up to 6in diameter by 12in long and, using an appropriate gauge three 4in hobs can be ground in one mounting. Hobs with from four to thirty-six gashes can be sharpened on this machine, the

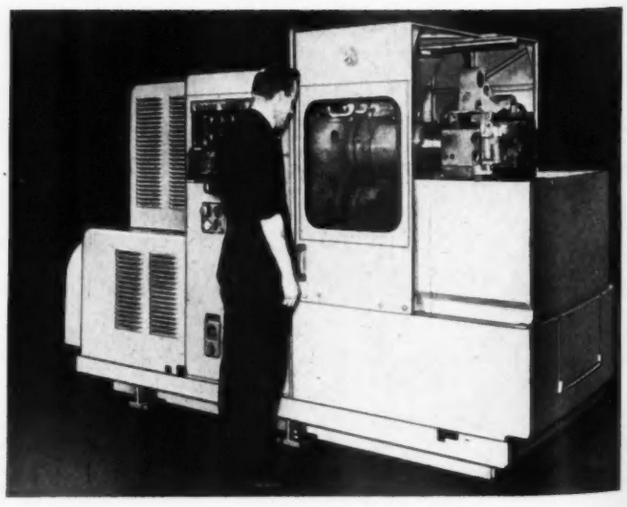


Fig. 4—Single spindle chucking automatic—Drummond Asquith

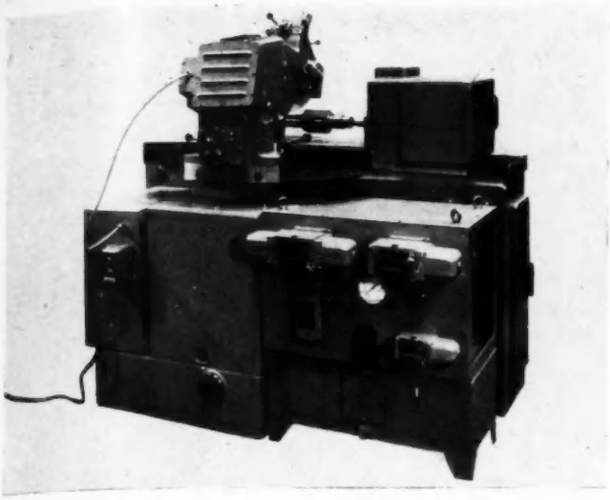


Fig. 5—Sharpener for hobs up to 6in diameter by by 12in long with from four to thirty-six gashes—David Brown

setting for lead of gash being obtained with a sine bar device built into the front of the machine and calibrated to one minute.

Hydraulic means of indexing is incorporated and an inter-lock prevents table movement until indexing is complete. Hand or automatic feed is provided and in both cases it is possible to grind in either direction, with feed rates down to a minimum of 0·0005in.

An improved model of the "Endomatic" component end milling and centring machine of Giddings and Lewis-Fraser, Ltd., Arbroath, is exhibited with a swing arm automatic loading and unloading device with associated shuttle and/or index input and output conveyors. The loader and unloader units with their conveyors are self contained and the shuttling conveyors, which eliminate the necessity of providing storage banks, are useful in linking together a series of standard machines. This machine can be supplied with beds giving varying lengths between cutters up to a maximum of 132in.

A new horizontal multi-cutter gear generator of W. E. Sykes, Ltd., Staines, has two separate independently adjustable cutter heads mounted on a common cutter slide. It cuts external spur gears 36–2½ D.P. and helical gears 36–3 D.P. externally on blanks up to 17in diameter and internal gears in blanks up to 12in diameter. A cluster attachment allows the simultaneous cutting of two gears of differing numbers of teeth or helix angles; alternatively one gear may be of spur form and the second helical.

Accurate control of the final cut rotation is provided on this machine by an electrical dial controller synchronised to the work spindle index worm. An adjustable knob on the dial controller allows the final cut to be set either more or less than 360 deg. as required. This facility allows the preliminary setting-up to be accomplished faster since, for example, the settings for a three cut cycle can be checked in about 120 deg. of work rotation. The adjustable work rotation controller is also used for segment gear cutting of any desired angle, a manually operated "feed reverse" lever allowing cutting in either direction thus avoiding unnecessary delay in resetting at the completion of each cycle. Control switches and a special sizing button allow a further saving of time when checking the final size of a component. When the trial cut is completed the gear is checked for size; after making any corrections necessary the "sizing button" is depressed to feed the component directly into finished depth.

An international metrology service which provides a range of measuring instruments has been arranged by the Taylor, Taylor and Hobson Division of Rank Precision Industries, Ltd., Leicester. Amongst the equipment on show is the Model 105 "Talysurf" which is designed as a portable and versatile means of measuring surface roughness. It provides CLA readings with 0·08mm cut-off and four measuring ranges are available (in English or metric): 0–0·15. 0-0·5, 0–1·5 and 0–5 microns. The instrument will measure the surface roughness inside a 6·3mm diameter bore to a depth of 279mm.

Other instruments shown include the model 2 "Talyrond" roundness measuring instrument which is designed to measure errors in roundness and concentricity on components weighing 450 kg and up to 1270mm long and 254mm in diameter. Roundness errors down to 0·025 microns are recorded on a polar graph, with radial magnifications up to ×10,000.

The principal exhibit of the Newall Engineering Co., Ltd., Peterborough, is a "Contimatic 1520" precision milling and boring machine incorporating the A.E.I. "Numeritrol" system for continuous numerical control of three axes. This machine (Fig. 6) has a 15in by 20½in table with longitudinal and cross traverse of 15½in and 10½in respectively. Its spindle has twelve speeds—67 to 3000 r.p.m.—and a stepless feed range from 0·33in to 7in per minute. The maker states that the machine has been developed to effect economies in the production of simple components, and to permit the automatic production of workpieces of complex shape, particularly those where accuracy of form and position associated with a superior finish is essential. These may entail a combination of machining operations, such as profile milling in two or three dimensions, co-ordinate milling, and hole making. The tolerances said to be achievable are 8 microinches CLA surface finish; 0·00025in maximum error from defined form; 0·0003in maximum error in distance between hole centres; and 0·00002in accuracy of repeatability.

The "Numeritrol" system not only provides for continuous control of all axes simultaneously, but may also govern a single motion or any combination of the movements available. Thus, for example, it may be used for conventional jig boring with positioning under tape control; it may also be employed for precision milling, under either manual or tape control. To overcome the problem of available cutters not being precisely the correct size, the system includes a cutter radius correction control which enables a correction for variation of cutter diameter to be set into the controller, thus modifying the tool path to one appropriate to the particular cutter in use. In addition, this control can be used to make roughing cuts.

Another automatic machine of interest at Brussels is the positional drilling machine of Wadkin, Ltd., Leicester, which has been designed for automatic operation from either punched tape or dial settings. Full advantage can, therefore, be taken of the high degree of accuracy provided by this method of operation and by savings made possible by the elimination of marking out and by dispensing with drilling jigs.

The machine comprises an all-geared vertical drill head mounted on a cross rail, which is, in turn, carried on twin columns with power rise and fall. It is capable of carrying out any number of positional changes to an accuracy of plus or minus 0·001in. The table is 42in wide by 66in long and has a longitudinal travel of 60in. The drill head unit is suitable for drilling holes up to 2in diameter in mild steel and has twelve spindle speeds ranging from 60 to 1500 r.p.m. with six feeds from 0·004in to 0·030in per revolution. As an alternative to the single spindle heavy-duty drill head a six-station turret head, demonstrated on the stand, can be supplied.

Two machines exhibited by George Richards and Co., Ltd., Altrincham, show how the firm, in redesigning its range of horizontal and vertical boring machines, has introduced centralised grouping of a minimum number of controls in conjunction with a pendant station. An automatic co-ordinate positioning equipment, controlled by either dial or tape is fitted in the horizontal machine.

(*To be continued*)

Fig. 6—Precision milling and boring machine incorporating "Numeritrol" control system—Newall

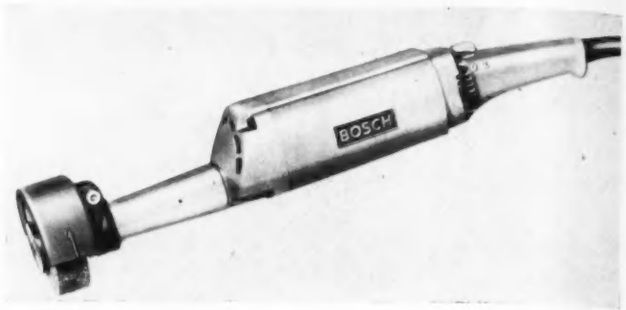
CONTINENTAL AFFAIRS *(Continued)*

Ronne-Copenhagen Ferry M.S. "Bornholm"

Our illustration shows the passenger ferry "Bornholm" which Burmeister and Wain has completed for Aktieselskabet Dampskibsselskabet pa Bornholm af. 1866. Built to the rules of Bureau Veritas the ferry has the following main particulars: length between perpendiculars 298ft 6¾in, breadth moulded 51ft 6¼in, depth moulded to upper deck 27ft 3¾in, deadweight 800 tons, draught aft 16ft 3in, trial speed 16·5 knots.

There are 333 berths for first class passengers for whom there are single and double berth cabins on the promenade, upper and main decks and two, three and four berth cabins on the 'tween decks. Also provided is an observation saloon at the forward end of the boat deck, able to seat fifty-nine passengers, and a dining saloon on the promenade deck having tables for five, six and seven and a seating capacity of 124. For the second class passengers there are on the upper deck two saloons, one to seat eighty and the other to seat fifty, with an after saloon having a capacity of thirty-four, while on the 'tween decks are two saloons each with forty-six places. Adequate open promenade space has been provided on the the boat and promenade decks. The number of unberthed passengers totals 593 and the ferry has a passenger certificate to carry a total of 1800 passengers on summer service in home waters. Accommodation for the crew numbering about fifty-two is mainly in single berth cabins, and there is a suite for the captain on the navigating bridge and a suite for the chief engineer on the boat deck. There is space for seventy-eight motor cars, and the forward hold spaces are served by two electric cranes while shell doors give access to the upper and main 'tween deck holds forward and to the main 'tween deck hold aft. Below the latter is a refrigerated hold.

The engine room is placed aft and the main propulsion machinery consists of a single-acting, two-stroke, directly reversible Burmeister and Wain cross head diesel engine mark 850-V.T.B.F.-110, having airless injection and forced lubrication. The unit has eight cylinders of 500mm bore by 1100mm stroke and has a normal output of 4600 b.h.p. at 170 r.p.m. Exhaust gases from the main and auxiliary engines are led to a secondary funnel at the main mast; the main funnel is used for ventilation purposes. Electric power required for auxiliary machinery and ship's services is supplied by three-425 KVA generators, arranged two to port and one to starboard of the main engine, each driven at 500 r.p.m. by a mark 625-M.T.B.H.-40 Burmeister and Wain, six-cylinder, single-acting, four-stroke, trunk piston diesel engine. To assist in manoeuvring the ship, a Kamewa controllable pitch propeller, driven by a 300 h.p. electric motor and hydraulically controlled from the bridge, is mounted in a transverse tunnel forward and can exert a thrust of 3·5 tons to port or starboard as required.



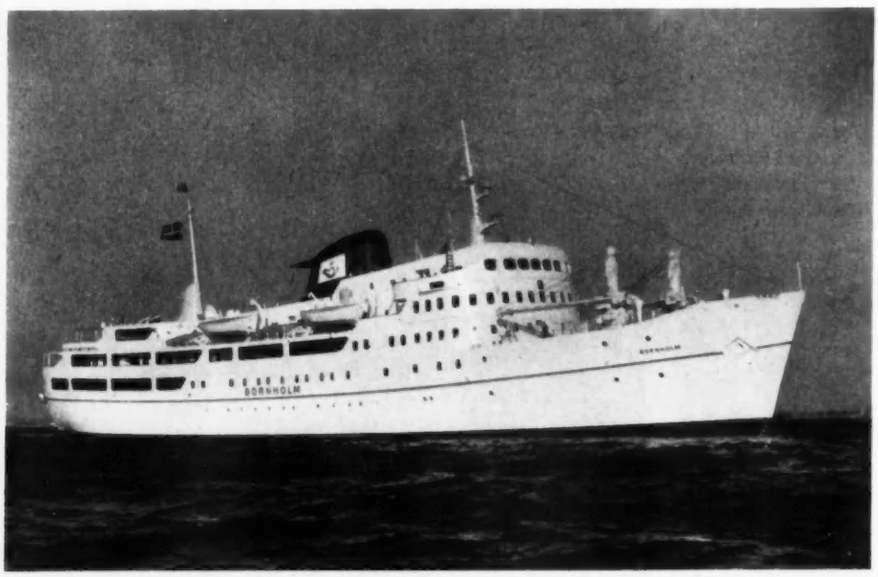
Portable high-frequency grinder

Metal Hardening Colloquium

The Seventeenth Metal Hardening Colloquium will be held from October 11 to 13 at Wiesbaden. The meeting, at which some thirteen lectures will be given, is being organised by the Wissenschaftlich-Technische Arbeitsgemeinschaft für Härterei Technik und Wärme-Behandlung e.V., Bremen-St. Magnus, P. O. Box 13.

Mechanical and Electrical Engineering Exhibition

The Biennial Exhibition of the Mechanical and Electrical Engineering Industries will be held at the Centre Nationale des Industries et des Techniques (C.N.I.T.), Paris-Puteaux, during the period May 25-June 3, 1962. It is being sponsored by the Syndicat Général de la Construction Electrique, 11, rue Hamelin, Paris (16e), and the Syndicat Général de la Fédération des Industries Mécaniques et Transformatrices des Météaux. At the C.N.I.T. the exhibition will adjoin the biennial French Machine Tool Exhibition. It will be held simultaneously with the "Expomat," the International Plastics Exhibition, and the Foire de Paris.



Ronne—Copenhagen ferry M.S. "Bornholm"

Portable Grinder

The series "EW/HS 77" portable grinders put on the market by Robert Bosch G.m.b.H., Stuttgart, comprises four machines operating on different voltages and frequencies of 150, 200, and 300 c/s. At a power consumption varying from 600W to 1150W they have full load speeds of 6000 to 18000 r.p.m. These plain grinders are suitable for small grinding wheels with integral shanks of 8mm diameter, or grinding discs up to 125mm diameter. Our illustration shows a model consuming 1150W at 300 c/s and running at 6000 r.p.m. It weighs 4·8 kg and is fully protected from dust.

Danish Oil Refinery

On August 18 the 46,000-ton oil tanker "Virginia Getty" arrived with crude oil at the oil refinery on Kalundborg Fiord, on the occasion of the official opening of the refinery. This is Denmark's first fully integrated oil refinery and is sited about 60 miles west of Copenhagen. The enterprise was undertaken by Dansk Veedol A.S., and includes main buildings by Foster Wheeler, Ltd. and a finger jetty by Christiani and Nielson. There are fourteen pipelines and a pumping installation able to handle 4500 tons of crude oil per hour. Air cooling has been adopted, which reduces the amount of fresh water required from 100,000 to 2000 litres per minute, and the annual power consumption is estimated at 50,000,000kWh. The initial capacity of the refinery is 20,000 barrels per day and the design provides for the throughput to be doubled without interrupting normal operation. Two electronic control centres regulate all manufacturing processes, based on information from 200 measuring devices, all impulses from the electronic controllers being converted into pneumatic pressure at valves, &c. On the site are 300 miles of pipeline and thirty-two storage tanks having a total capacity of 250,000 tons, while marine terminals for local distribution having an overall capacity of 150,000 tons have been built at Aalborg, Frederikshaven, Copenhagen, Odense, Aabenraa, and Aarhause.

Plastics and Rubber Conference

The first European Plastics and Rubber Conference will be held in Paris from May 18 to 29, 1962, under the auspices of the International Union of Pure and Applied Chemistry. Sessions will be devoted to reinforced plastics, research, manufacture, transformation, application and technical economics, as well as to plastics in agriculture and mixed rubber-cum-plastic materials. Information may be obtained from Du Mont Publicity Company, 18, Queensberry Place, London, S.W.7.

Plant for Industrial Glassware

Q.V.F. Glastechnik G.m.b.H., German subsidiary of Q.V.F., Ltd., industrial engineers in glass of Stoke-on-Trent, are building a 41,000 square foot factory at Wiesbaden-Schierstein due to be completed this autumn. The factory, which will employ between eighty and 100 men and women, will replace existing premises in Wiesbaden-Biebrich.

THE AMERICAN SCENE

By Our American Editor

Nuclear Power Progress

THE commerical application of nuclear power in the United States took an important step forward last month, when the General Electric Company announced that it is putting on the market a standard line of nuclear power-generating stations ranging in capacity up to 500MW. Henceforth, electric utilities will be able to order "off-the-shelf" reactors at what amounts to a list price. Capital investment, depending on the size of the plant, will run between 165 dollars and 200 dollars per kilowatt, a level low enough to provide power as cheap as that from conventional sources in many highly-populated areas in the United States. Only a few weeks ago, the company contracted with the Pacific Gas and Electric Company to build at a cost of 61,000,000 dollars an atomic power plant at Bodega Bay, California, which will turn out 325MW of electricity by 1965 at a record low cost of 5·6 mills per kilowatt-hour (1 mill=0·001 dollars). With its latest announcement, the firm has dispelled any lingering doubts about the peaceful uses of the atom.

To-day, American industry is committed deeply to the taming of the atom. Yet in view of the Government's far more publicised activities, the public hardly appreciates the extent of this commitment. By now, five civilian power reactors, with a total capacity of some 360MW, are in operation. By the end of the year, five more, adding some 300MW, will be in use. Next year should see another comparable increase in capacity, bringing the total close to 1000MW. Plans for still another 1000MW to be added before 1966 have already been announced. As significant as the quickening pace of atomic outlays is the mushrooming technology responsible for it. True, full-scale competition with conventional power is still some time off. Indeed, the nearly 2,000,000kW of nuclear capacity now in the offing barely comes to 1 per cent of current U.S. electric generating capacity; three or four years hence, if conventional power continues to expand at the present rate, it may account for less than 1 per cent. The evidence suggests, however, that the atom, under the pressure of private initiative, already has become the focus of a vigorous rivalry among reactor manufacturers and suppliers.

Among the various types of power reactors, five seem to be nearest to attaining the common objective of cheap nuclear power: organic, sodium, pressurised water, boiling water and gas cooled. In organic-cooled reactors, where North American Aviation has taken the lead, a waxy substance serves as both coolant and moderator. The first American organic reactor is nearing completion in Piqua, Ohio. Delayed by an eighty-five-day plumbers' strike, it will not go critical this year, as had been hoped. In 1962, however, it will become the first atomic power station to be operated by a municipal utility. In Piqua, in contrast to other, more densely populated areas, the Commission and the contractor encountered no substantial public resistance. North American now has received a second offer: a group of thirteen West German utilities, centred at Mannheim, has ordered preliminary designs for a 150MW reactor, which the company believes may achieve competitive costs.

A second major type of reactor uses sodium as a coolant and graphite as the moderator. Compared with organic-cooled reactors, the sodium design offers still higher temperatures and lower pressures. Its drawbacks are a certain sluggishness, requiring heavier pumps, and a susceptibility to corrosion. A first version of the sodium reactor was designed for the nuclear submarine "Seawolf"; because of its corrosiveness and relatively complicated plumbing the plant was dismantled in 1959, after several unsuccessful sea trials. Troubles of another sort assailed the second sodium plant, the Enrico Fermi fast-breeder, now being erected near Detroit. The idea was to breed plutonium, at a ratio of 1·2 to 1, while the fuel was being consumed—thus, actually to multiply fuel during the reactor process. As originally drawn up, the project was to cost 47,000,000 dollars; by now, the project has almost doubled in price. Technology admittedly has been difficult on this complex scheme. That fact, however, is not wholly to blame for its tremendous cost inflation. The real trouble has come from several local trade unions—the Paper Workers; the Electrical, Radio and Machine Workers; and the United Automobile Workers. During most of 1957, an A.E.C. examiner held hearings on their charge that safety requirements had not been met in the Enrico Fermi design. In 1958, the Commission rejected the charge and ordered the construction permit reconfirmed; then in mid-1960, a three-judge Federal panel set aside the permit. Recently, the Supreme Court approved the jurisdiction of the A.E.C. thereby establishing a precedent that may deter future strife of this kind. The target date for the completion of the 100MW plant now is December. The industry is eagerly awaiting its start-up, since several new concepts will then undergo important tests. In addition to the fast-breeding technique, the plant will use an extremely enriched uranium in its core. Since the Fermi plant will be by far the largest to use sodium as a coolant, operating experience from that standpoint alone will be of great significance.

Coming onstream next year will be the sodium reactor plant at Hallam, Nebraska, designed and built by the Atomics International Division of North American Aviation. This firm recently also announced an approach to competitive nuclear power, based on its Hallam facility. Such a plant would have the "highest degree of inherent safety of any nuclear reactor concept and is designed to achieve higher performance than any power plant currently in operation or proposed." North American claims that its calculations show a 360MW facility able to go critical by 1967-68. The company estimates that power costing 6·2 mills could be generated from the outset, "with the promise of substantial fuel cycle cost reduction during the operating life."

In the field of pressurised water reactors, the leading American proponent, and builder of all but two of the U.S. Navy's forty-six submarine reactors so far authorised, is Westinghouse. In 1957, the company brought in the world's first large-scale nuclear power station for civilian use, the Shippingport reactor, near Pittsburgh. Shippingport never pretended to be aiming at competitive costs; indeed, its design intentionally included oversized plumbing and other components, to make possible easy access for testing and maintenance. The massive plant, however, has served its purpose, founding the technology not only of land-based pressurised water reactors but also of much of the rest of atomic power development. Officials of the Yankee Atomic scheme, the next large pressurised reactor to come onstream, said of Shippingport's developers: "We're standing on their shoulders." Last year, Yankee itself went critical. Using another Westinghouse reactor, this project achieved operational status fully two months ahead of schedule. This summer it went up to full load, 120MW, and it has requested approval of the A.E.C. to boost output capacity to 145MW. While still operating on its first core, it expects to get the cost per kilowatt-hour down to 11 mills—close to New England's conventional fuel costs of 9 to 10 mills.

On the Hudson River stands the project of another specialist in pressurised water technology, Babcock and Wilcox. The Indian Point reactor of Consolidated Edison, 24 miles upriver from Manhattan, will be the first in New York State when it goes critical later this year. And even though Indian Point is not expected soon to produce competitive power, it will be remarkable on several counts. For one thing, it will be the first large reactor to convert thorium into the uranium isotope U-233, to achieve high fuel efficiency. A second significant feature of Indian Point is its oil-fired superheater, which will raise the temperature of the steam from 449 deg. to 1000 deg. Fah., nearly doubling generating capacity from 151MW

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to 255MW. It thus will be the first American water-cooled reactor to achieve superheat. Westinghouse recently concluded an agreement with the Southern California Edison Company to build an even larger, 360MW plant, of pressurised design, on land belonging to the U.S. Marine Corps at Camp Pendleton near Los Angeles. The Pendleton reactor will offer potent proof that the old pressurised water technology still has vitality. If the road blocks in Washington are cleared promptly, it will go critical by January 1, 1965, to achieve the distinction for the time being as the biggest commercial reactor on earth. Also, its three-cycle system will permit continuous operation even when part of the plant is shut down for maintenance. Finally, it stands a chance of being competitive with fossil fuels.

Just as one connects the Westinghouse name with pressurised water reactors, so General Electric is usually associated with boiling water reactors. The first BWR was the experimental one built by the University of Chicago's Argonne National Laboratory in 1956. Out of this, in less than five years, developments have come so quickly that boiling water reactors on land to-day outnumber the pressurised water variety, as well as every other kind. In the main, the companies responsible for this incredible showing are General Electric, Allis-Chalmers and Combustion Engineering. By and large, Allis-Chalmers has given General Electric the most strenuous run for its money. Most ambitious is the Allis-Chalmers contract with the Northern States Power Company, to build a 66MW BWR on the Big Sioux River in South Dakota. The project will incorporate an integral nuclear superheater —the largest of its kind when it goes critical, supposedly next summer. Pathfinder, as the project is called, will have a compartmented reactor ; the outer section to heat the water to boiling and the inner one to raise the steam temperature from 489 deg. to 825 deg. Fah.

In the supercharged atmosphere of boiling water technology, though, General Electric is bringing the most heat to bear these days. The big 180MW Dresden nuclear power station it built for Commonwealth Edison went critical in 1959 and reached its full power load on June 29, 1960. Since then, as the first large-scale civilian power reactor, it has been providing the only log by which the utilities could gauge just how atomic energy stands up on-line over the long run. Considering that Dresden provides saturated steam of only 457 deg. Fah., no one ever expected the plant to provide competitively priced power. Dresden was the firm's first large reactor project, but many more have followed. To-day, for example, it has at least four contracts overseas—one in Japan, another in West Germany, and a third in the Netherlands. Most important is one for a 150MW power station, now under construction and scheduled for operation in 1963, for a group of utilities in Italy. The latter will be the first large-scale unit on the Continent and is being supported in part by both Euratom and the A.E.C.

General Electric's most important developments have resulted from a unique joint effort with the Pacific Gas and Electric Company. In 1957, the Vallecitos atomic power plant went onstream as a prototype of what was to come. Vallecitos has been a fertile breeding ground for ideas—as well as a generator of 5MW of electricity. Currently, the first General Electric nuclear integral superheater is about to be constructed there, as part of a step-by-step compaign of boiling water development, financed privately, which the company several years ago named " Operation Sunrise." The first major offshoot of Vallecitos was the 50MW reactor for the Pacific Gas and Electric Company at Humboldt Bay. The latter's entire cost, some 19·5 million dollars, was paid by the California utility, and operation is expected to begin next summer. Among other things, it will provide the first practical demonstration of the technique of " pressure suppression." The entire reactor is constructed inside a concrete tank filled with water ; should any radiation escape the core, the water deadens it to protect the rest of the plant and the surrounding countryside. Furthermore, Humboldt Bay will be competitive. Though estimated costs of 10 mills per kilowatt-hour would not be cheap in most other U.S. areas, the carefully selected site on the shallow bay—where oil would have to be barged in—proved an exception.

Obviously, then, the 325MW Bodega Bay reactor just announced by the same two firms portends even more striking progress. The project did not lack for direct competitive bidding : both Combustion Engineering and Allis-Chalmers were eliminated after participating enthusiastically. Bodega Bay will employ many of the advanced features of Humboldt Bay, even though the latter still is abuilding. The Bodega Bay reactor will be a steel and concrete structure 120ft in diameter and 100ft deep ; it will be constructed underground, using the earth itself as shielding. Also, it will demonstrate more efficient high-power generation through the concept of forced circulation ; previous boiling water designs used natural circulation. Finally, Bodega Bay will contain an internal steam separator, to remove dry steam from water within the reactor rather than in a special vessel above it. On the site, which is 50 miles north of San Francisco, Pacific Gas and Electric has estimated that a conventional power plant using oil at the present cost of 2·25 dollars a barrel would produce electricity at 5·77 mills per kilowatt-hour ; if oil were at 3·00 dollars, the cost would rise to 6·82 mills. The utility thus decided to go ahead with a nuclear design for Bodega Bay on purely economic grounds : the first enriched uranium core, to last three years, will provide power at 5·62 mills ; on the second charge, the cost will drop to the lowest level yet estimated for atomic power anywhere, 5·32 mills ! This achievement was made possible not only by many engineering developments but also by a recent decision of the A.E.C. to reduce its prices for enriched uranium by 20 to 34 per cent.

Emboldened by these prospects, General Electric even last spring was claiming that it could design and construct large-scale nuclear power plants for many areas of the country that would be competitive in cost. Then in June, Pacific Gas and Electric announced Bodega Bay. Finally, General Electric released its atomic bombshell, making available to utilities for immediate construction a standard line of reactors in sizes ranging from 100MW to 500MW. The company said it would quote firm prices, varying only according to site. Designs for competitive boiling water plants thus have been frozen for the first time, at least for now. However, the company has no intention of abandoning its large research and development programme and it will continue to centre on boiling water technology. With more progress to come, in short, the era of competitive atomic power is here.

General Electric's next real competitive test for its boiling water principle will come in New York State by the end of 1963. A combine of seven utilities, called Empire State Atomic Development Associates, then will choose between two major design proposals for a large-scale power plant to achieve costs below those of fossil fuels. Boiling water will compete with the emerging technique of gas cooling, which had its origin at Calder Hall. Many experts in the American industry believe that gas-cooled reactors represent the wave of the future for the atom. Two projects now are in the works. At Oak Ridge, with Allis-Chalmers and Kaiser Industries as design contractors, the A.E.C. is building a helium-cooled, graphite-moderated experimental reactor of 22MW capacity. Because of the far higher heat-conducting properties of the gas, the plant will produce steam of some 900 deg. Fah. at pressures of 1300 lb per square inch. It is expected to be critical next year.

An even more important development is going forward under the auspices of private industry. At Peach Bottom, near Philadelphia, a utility combine called High Temperature Reactor Development Associates, headed by the Philadelphia Electric Company, is building a 40MW high-temperature, gas-cooled reactor. Due onstream in 1963, the scheme is under the direction of the Bechtel Corporation, with the reactor being designed and built by the General Atomic Division of General Dynamics. The project will generate steam of 1000 deg. Fah. at pressures of 1450 lb per square inch—both figures being the highest yet for any civilian American power reactor. It is predicted confidently that the steam will produce power for Philadelphia Electric for less than 7 mills, with a goal of under 6 mills three years after operation begins. No other reactor in the East of the United States has approached this level.

Under private auspices, nuclear energy thus is beginning to have an explosive impact. On the distant horizon things look brighter than ever. Manufacturers are rapidly expanding their knowledge, and markets, through a growing output of small research reactors for university and industrial laboratories. Out of such experiments the uses of radio active isotopes are multiplying almost daily. Elsewhere, projects are going forward that would apply fission heat to the processing trades, such as paper and chemicals. In the quest for outer space, others are trying to develop the atom as the only foreseeable source of power for inter-planetary travel. Finally, private enterprise even now is trying to harness the energy of thermonuclear fusion. Summing up, it may truly be said that the era of competitive nuclear power, undreamt of a decade ago, is about to begin.

Saline Water Conversion Plant in Texas

The first water conversion demonstration plant completed by the Office of Saline Water, of the U.S. Department of the Interior, was recently dedicated at Freeport, Texas. The installation produces drinking water from the sea water of the Gulf of Mexico, employing the long tube vertical multiple-effect distillation process. It has a capacity of 1,000,000 *U.S. gallons per day and produces about* 9·5 *lb of water per* 1000 *B.Th.U. of heat consumed. The current conversion cost of the process is only* 1 *dollar per* 1000 *U.S. gallons of water produced.*

DEDICATION ceremonies at the saline water conversion demonstration plant in Freeport, Texas, were held on June 21. President Kennedy participated by addressing those assembled in Freeport for this ceremony via a special long-distance telephone arrangement from the White House in Washington, D.C. In addition, the President pressed a button which closed an electric circuit and placed the plant into full-scale operation.

The Freeport plant is the first of five saline water conversion demonstration plants authorised by Congress in 1958. The construction of demonstration plants at San Diego, California, and Webster, South Dakota, is in hand, and construction contracts for plants at Roswell, New Mexico, and Wrightsville Beach, North Carolina, are scheduled to be awarded later this year. In view of the shortage of water in arid areas of the United States and elsewhere, Congress had provided for the development of low-cost means of producing from sea water, or from brackish waters, water of a quality suitable for agricultural, industrial, municipal, and other beneficial consumptive uses on a scale sufficient to determine their feasibility of production and distribution on a large-scale basis to conserve and increase the water resources of the country. Under the provisions of an Act approved by Congress in 1952, the then Secretary of the Interior, Oscar L. Chapman, established an Office of Saline Water to develop new conversion processes by means of research grants and contracts; to conduct research and technical development work ; to make careful engineering studies to ascertain the lowest investment and operating costs ; and to determine the best plant designs and conditions of operation.

Office of Saline Water

The Office of Saline Water is a good example of co-operative endeavour between a Federal agency and private research and industrial firms. Its work is carried on under two separate funds : one for research and development and one for construction. The research and development activities are carried out by means of negotiated contracts or grants with universities, industrial organisations, research institutions, Federal laboratories, and individuals. All construction contracts, on the other hand, have been let by competitive bids. During the past year, over sixty contracts were negotiated and managed by only fourteen staff engineers. Interest in the saline water conversion programme has been stimulated by the publication of technical papers, etc. Up to this time, the programme primarily has been an engineering development effort. Emphasis has been placed on the development of existing processes through engineering investigations, construction, operation, and the study of pilot plants.

Since the initiation of the programme, the cost of converted water has been reduced from about 5 dollars to 1 dollar per 1000 U.S. gallons. However, because of present effort, the programme is approaching the flat portion of the asymptotic cost curve. During the past few years the cost of conversion has been reduced by dollars, but the cost curves predict that in future it will be as difficult to lower the cost by 10 cents as it was to cut the cost by a dollar in the past.

The Division of Processes Development of the Office of Saline Water has current major interest covering the following (1) Distillation with the use of fuels ; (2) solar-heat distillation ; (3) membrane processes ; (4) separation by freezing ; and (5) other chemical, electrical, or physical conversion methods.

Several of the distillation processes are the furthest advanced to-day. For example, new large commercial installations in water-short areas have been announced, with multi-stage flash distillation being the preferred process for converting sea water ; however, research and development of other distillation processes continue, in order to lower costs further. Pilot equipment is being operated on sea water to develop methods of scale control. A prototype unit of a new wiped-film evaporator is being built. Solar distillation pilot units are being operated to determine ways of reducing capital costs and increasing efficiency of energy use.

Membrane processes continue to show promise as future important means of converting saline waters, particularly of lower salinity. Research and development is being carried out at the Bureau of Reclamation Laboratories in Denver on electrodialysis. Membranes are being studied, and five different types of electrodialysis units have been procured and are being evaluated. A field test site with brackish well water available has been established.

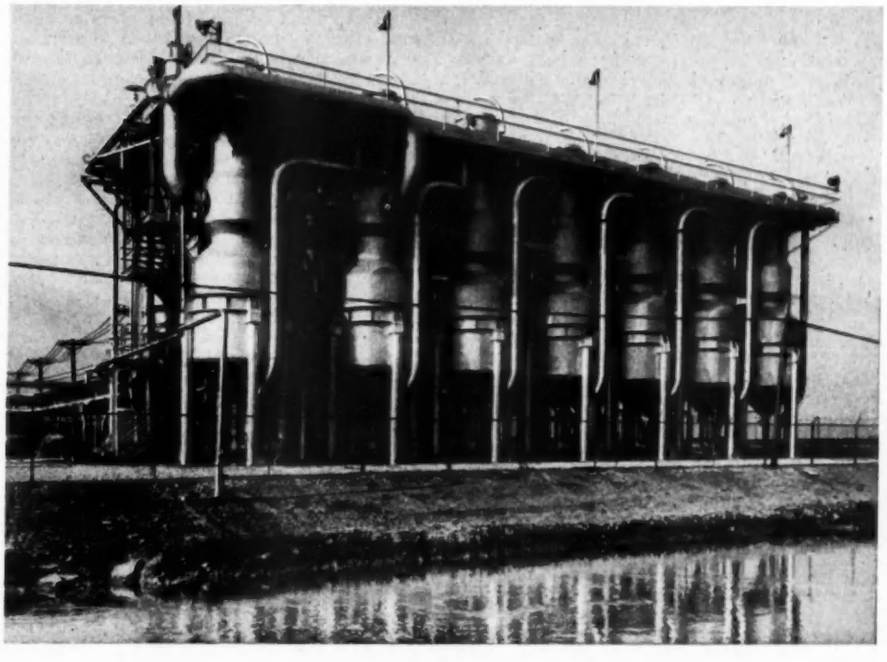
During the past year a major part of the development effort has been on freezing processes. These have only recently reached pilot plant stage of development. Direct freezing processes have been shown to be the most advantageous. Data obtained so far support the previous predictions that fresh water obtained will be competitive in cost with the more advanced distillation processes. A 15,000 U.S. gallons per day pilot plant using one kind of freezing process is now operating on sea water at Wrightsville Beach, North Carolina. Another freezing pilot plant using a secondary refrigerant system, and designed to produce 35,000 U.S. gallons per day, is starting operations at St. Petersburg, Florida.

Distillation Processes

Because distillation has been extensively used to obtain fresh water from saline waters, it was generally thought that most of the improvements for distillation equipment had already been developed or were under study. This, however, was not the case.

The Office of Saline Water stimulated new research to develop improved distillation processes for selected types of (1) vapour-compression evaporators, (2) long-vertical-tube multiple-effect systems, (3) multiple-effect flash systems, and (4) nuclear-energy-evaporator combinations. The results of these studies are promising if certain conditions in the operation of these distillation systems can be achieved. A parallel series of research and development projects has also been advanced in the fields of heat transfer, scale-deposition prevention, and materials suitable for extending the life of a distillation plant under certain operating conditions. Those studies and researches, although limited by the funds available, are continuing in order to develop conclusive results necessary for the engineering design of full-size plants. As a result, there is every indication that distillation equipment will be developed that should be capable of low-cost salt water conversion, provided the research and development projects are successful. Progress in conversion cost reduction by means of distillation has been made and will continue. Before World War II the cost of producing fresh water from sea water ranged upward from 4.00 dollars per 1000 gallons. The conversion costs recently were about 2.00 dollars per 1000 gallons, and it is anticipated that the cost per 1000 gallons from the new Freeport demonstration plant of one million gallons per day will be only 1.00 dollar. This cost has been achieved in spite of the rising cost of labour and materials.

Research efforts have been directed toward the development of evaporators capable of producing converted saline water at still lower costs, provided they are operating with (1) clean heat-transfer surfaces, (2) high rates of heat transfer, (3) low temperature differences between heating and cooling fluids, and (4) designs that will utilise improved construction techniques and take full advantage of the first three items mentioned. For example, the long-tube vertical multiple-effect distillation process incorporates a new method of scale control known as sludge recirculation. This method will maintain clean heat-transfer surfaces and will ensure the high



Saline water conversion plant of 1 million gallons per day capacity at Freeport, Texas

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rates of heat transfer necessary for efficient operation of the plant. This process will receive its first major test in the sea water conversion demonstration plants at Freeport, and San Diego. In addition to this development there have been important commercial developments in multi-stage flash distillation, both in application for marine uses and for large land-base plants. These developments and the results of design studies sponsored by the Office of Saline Water, which included possible combination with nuclear-process steam reactors, led to the selection of the improved flash evaporation process for the second plant at San Diego.

Long Tube Vertical Evaporator

Long tube vertical (L.T.V.) evaporators have been used for many years in the chemical industry for the concentrating of liquors, such as waste sulphite in the pulp industry. The design represents one of the cheapest forms of heat transfer surface per dollar of installed cost and per unit of energy required for operation.

The use of an L.T.V. evaporator design for desalting sea water was first suggested by W. L. Badger, of Ann Arbor, Michigan, to the Office of Saline Water in 1955. In 1957 an L.T.V. pilot plant of 2000 gallons per day capacity was erected and extensively tested at the International Nickel Company's Corrosion Research Laboratory, at Wrightsville Beach, North Carolina. The experimental work was under the direction of the Office of Saline Water and W. L. Badger Associates. The test work resulted in the design of a twelve-effect evaporator saline water conversion process which was selected for the first demonstration plant on March 2, 1959, as one of the most promising of the presently known processes for the large-scale economical conversion of sea water to fresh.

One of the most important features of this process is the method of scale control being utilised. One method is pH control, which is accomplished by adding chemicals and treating the water in such a way that the acidity and alkalinity of the water remain neutral throughout the system. A second technique, called the slurry method, was developed during the early pilot plant tests at Wrightsville Beach. The slurry method of scale control utilises fine crystals or seeds of scale which are recycled in the sea water-brine circuit. Scale precipitating out of the brine solution tends to form on the crystal seeds rather than on the metallic heat transfer surfaces. In this way, fouling of heat transfer surfaces is minimised and corrosion reduced.

W. L. Badger and Associates has conducted research and development tests with a long-tube-vertical (L.T.V.) pilot plant evaporator at Wrightsville Beach, North Carolina. Besides scale control and corrosion tests, information was sought on the factors that influence heat transfer in the L.T.V. evaporator. Heat-transfer studies were made with both 1in and 2in diameter tubes, 24ft long. It was found that the coefficients for the 1in tube were lower than those for the 2in tube under all conditions of operation. Also, it was discovered that an increase in the feed rate for the 1in tube lowered the coefficient; the opposite was true for the 2in tube. Therefore, it may be expected that greater economy will be obtained with the present design of the Freeport demonstration plant using the 2in tubes.

A series of test runs was made to determine how the overall heat-transfer coefficient is affected by several variables in the evaporator operation. This was done by making a statistical analysis of data from thirty-two random runs. Five factors were studied to determine their effect on the heat-transfer coefficient. Of these, the boiling point was shown to have the greatest effect and the other factors were, in this order: feed rate, feed temperature, feed concentration factor, and steam rate. However, the analysis showed that none of the factors is completely independent.

During the past year, several runs were made using a calcium sulphate sludge to prevent calcium sulphate scale. The results of these tests indicate that there is considerable uncertainty as to the proper type of calcium sulphate sludge to be used for specific evaporator conditions. Erratic operation of the L.T.V. evaporator at the higher temperatures (>250 deg. Fah.) was encountered, such that the results of the sludge tests were inconclusive. As a result, the pilot plant was shut down for maintenance in order to improve operation at the higher temperatures. Experimental work with the prevention of calcium sulphate scale is continuing under conditions more severe than would be encountered at the demonstration plant. Attempts will be made to develop scale-prevention techniques with temperatures as high as 300 deg. Fah.

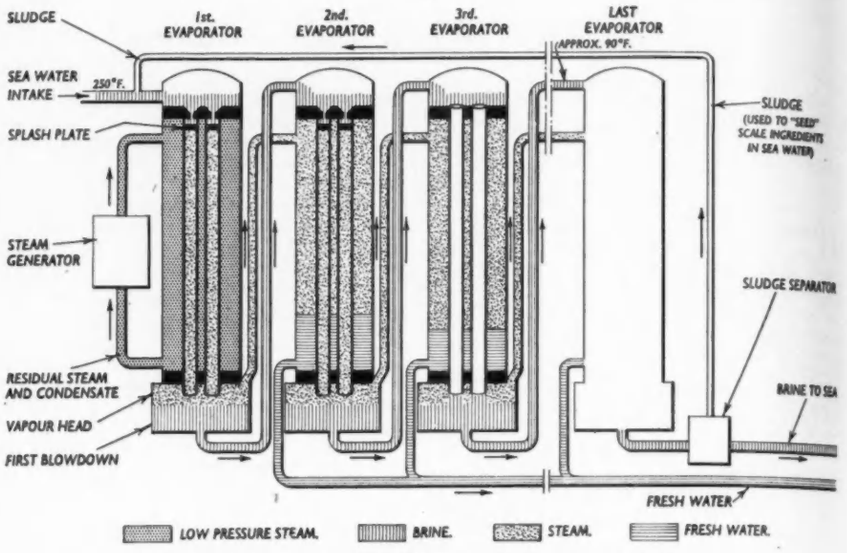


Diagram of long tube vertical distillation process employed at Freeport

Plant Construction

Funds were made available for the design of the first three demonstration plants in the fiscal year 1960. As a result of their previous experience in the study and development of particular processes, contracts for architect-engineering services were granted after negotiation with the following: (1) W. L. Badger Associates, Incorporated, of Ann Arbor, Michigan, for the Freeport plant; (2) The Fluor Corporation, of Los Angeles, California, for the San Diego plant, and (3) the U.S. Bureau of Reclamation at Denver, Colorado, for the Webster plant. Competitive bids were called for the Freeport plant on April 1, 1960, and bids were opened on May 24, 1960. The Chicago Bridge and Iron Company, with a low bid of 1,246,250 dollars (which includes experimental features and start-up costs), was awarded the Freeport contract. The specifications called for construction and start-up operations to be completed in 330 days, 270 days for construction and sixty days for operational testing under warranted conditions before acceptance of the completed plant.

The construction contract for the Freeport plant was awarded to the Chicago Bridge and Iron Company on June 7, 1960. The contract provided for the completion of the plant in March, 1961. The plant uses the long-tube vertical twelve-effect distillation cycle, and was designed to produce 1,000,000 U.S. gallons per day of fresh water. Approximately 9·5 pounds of water are produced per 1000 B.Th.U. of heat consumed. The unusual features of the plant include: (1) A high distillation temperature for sea water—250 deg. Fah. in the first effect down to 120 deg. Fah. in the twelfth-effect. (2) A falling film evaporation of the sea-water brine, avoiding temperature drop due to hydrostatic head. (3) High overall heat transfer coefficients ranging from 350 to 750 B.Th.U. per hour per square foot per deg. Fah., with an average value of 580 B.Th.U. per hour per square foot per deg. Fah. (4) A high degree of deaeration of the incoming sea water to remove oxygen to a few parts per 1000 million. (5) A concentration factor of four to one, just below the temperature and concentration for calcium sulphate scale formation. (6) The use of steel in the major components, where absence of oxygen in the water has been demonstrated to reduce corrosion materially. (7) The use of magnesium hydroxide slurry to prevent scale formation of this constituent.

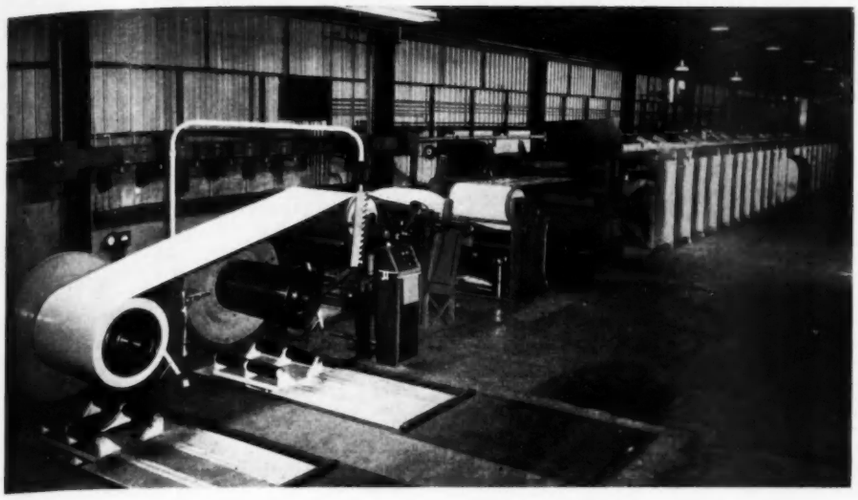
The experimental features of this plant include devices to increase the operating temperature to 300 deg. Fah. If successful, the plant would be capable, with modifications, of producing 70 per cent more product water than at 250 deg. Fah. Facilities are provided to use acid pretreatment as another means to prevent magnesium hydroxide scale formation. Tube materials will be evaluated by providing some of the evaporator and heat exchanger tubing of admiralty alloy, aluminium brass, and 90–10 copper-nickel alloy. The copper-nickel alloy will be used in the sea water exchangers served with oxygen in sea water.

Plant Operation

At Freeport, steam is supplied by the Dow Chemical Company and is admitted into the first evaporator or effect. The steam fills the space around and outside of the tube bundle causing part of the sea water to boil as it falls through the tubes. Emerging at the bottom of the evaporator there is a mixture of vapour and hot brine. The hot brine is pumped to the top of the second evaporator where, under slightly reduced pressure, it again falls through the inside of the tubes.

The vapour produced in the first effect flows to the outside of the tube bundle in the second effect. Here the vapour is condensed to fresh water by giving up its latent heat of vaporisation to the sea water falling through the tubes which again causes part of the water in the tubes to boil. This same process is repeated through all twelve-effects of the plant. The condensed vapour, which is fresh water, is pumped from each effect into a common line leading to the storage tank. The remaining brine in the last effect is pumped back into the Dow Chemical Company's sea water flume for discharge into the Gulf of Mexico.

Coating Line for Aluminium Strip



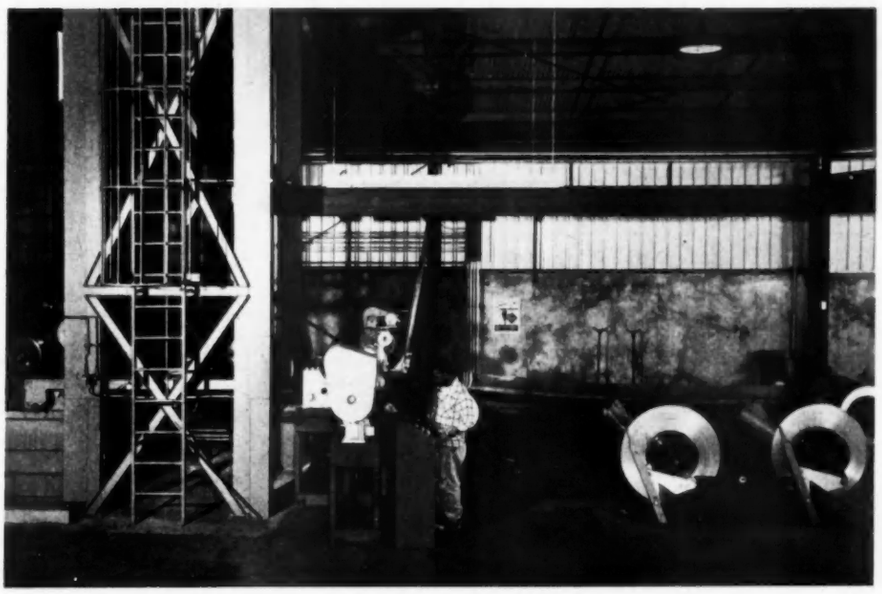
A NEW 36in wide continuous strip painting line that applies both a primer and a finish coat to coiled aluminium sheet in uninterrupted sequence recently went into commerical operation at the Riverside, California, works of the Hunter Engineering Company. The line was designed and built by the firm to produce superior quality painted sheet, with good corrosion resistance, formability, gloss control and colour control. The 325ft long painting line is claimed to be the first one to give two completely cured coats to 36in wide strip in one continuous operation. The two coats mean greater versatility for the finished sheet and better control of the dry film thickness.

The primer coat of epoxy resin forms a corrosion barrier which effectively resists cracking and peeling under severe conditions of forming and fabricating. With many finishes, corrosion can "creep" under the finish when the original barrier has been broken. The primer used by Hunter Engineering is said to adhere so intimately to the metal surface that, when the primer film is broken, corrosion is restricted to the exposed metal and cannot creep into adjacent areas covered by primer. This feature even protects the exposed edge on metal which is slit after painting.

The constituents of the epoxy primer are so finely ground that one can note the absence of "teeth" in the primer coat which have been considered necessary for mechanical adhesion of the finish coat. But, according to Hunter, the smooth, uniformly thick primer coat bonds the finish coat so intimately that specialists have have not been able to separate the two coats mechanically. Also, the finish coat derives uniform colour, gloss, and a very smooth surface from the primer.

The new line will continuously paint 36in wide coiled sheet in gauges from 0·010in to 0·051in at speeds up to 80ft per minute. The sheet travels from tandem pay-off reels through a double-pass, 30ft high accumulator tower and into three pretreatment tanks (as illustrated). The first bath cleans the strip with a detergent wash ; the second stage de-oxidises the metal surface ; and the third applies a conversion type of pretreatment coat to the metal suface to prepare the surface for the paint. On the exit side of each tank, squeegee rolls, a clear water rinse, a water blast and another set of squeegee rolls remove solution from the strip surface to minimise carry-over and prevent contamination.

The strip is dried by a chevron air dryer after leaving the last tank and prior to entering the first paint room. Here, a roller coating machine (below left) applies the epoxy primer to either or both sides of the strip. The paint rolls can turn in either direction to give either a forward or reverse coating action. The primer coat thickness is nominally 0·0002in when cured, but can be varied from 0·0001in to 0·001in and can be controlled within plus or minus 0·00005in. The primer is cured when the strip is passed through a 60ft oven in which the temperature is closely controlled between 550 deg. and 650 deg. Fah., depending on the requirements of the specific finish being applied.

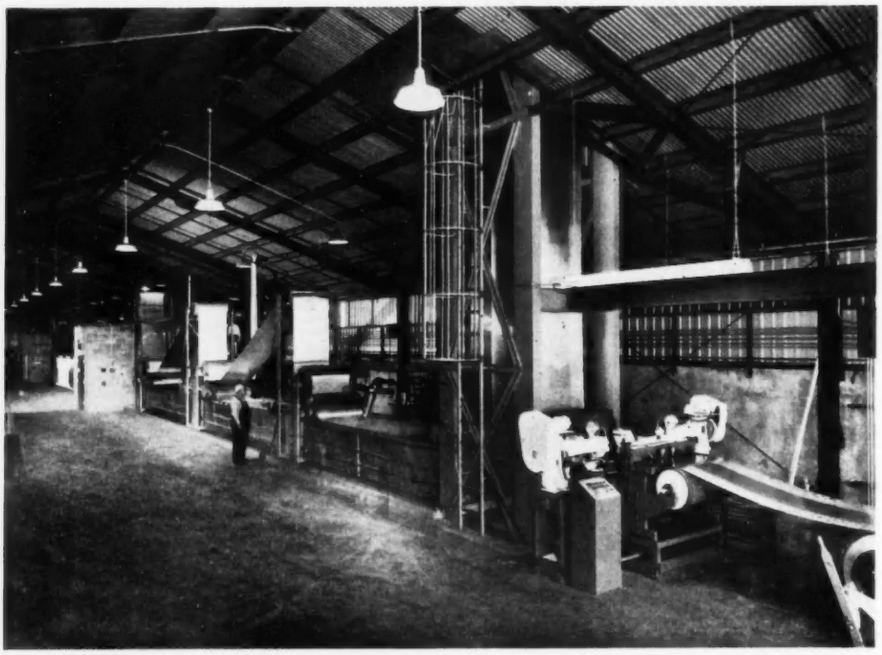


Continuous roll coating line. (Top Left) 70ft long paint curing oven, strip embossing station, shear and tandem rewinders with collapsible mandrels (Right) Tandem pay-off reels and double-pass accumulator tower at start of line (Left) Coating machine in first paint room for the application of primer paint

The primed strip is air cooled as it passes from the primer curing oven to the second paint room where the finish coat is applied. The second machine will paint either one or both sides of the strip, and apply the same or different paint colours on each side of the strip. While the strip is travelling, a change-over from one colour to another on the top surface can be made within a strip length of only about ten feet. As the strip leaves the second paint machine the finish quality reflects the advantages of priming over single coat painting—close control of film thickness and colour uniformity. The finish coat is so tightly bonded to the primer, that there appears to be a chemical action between the paint and the primer.

The total film thickness of paint and primer is nominally 0·001in but can be varied from 0·0003in to 0·002in. A tolerance of 0·00005in

THE AMERICAN SCENE *(Continued)*



Strip shear, stitchers and accumulator tower ahead of triple pretreatment tanks

is maintained across the full width of strip. The firm has selected alkyd melamine enamel as its standard finish for the best all-round performance, but also applies acrylic, vinyl and vinyl organosol finishes. A "wash coat" is applied on an unpainted side.

The painted strip passes through the final 70ft curing oven (illustrated), in which temperature is closely controlled between 450 deg. and 550 deg. Fah., depending upon the requirements of the finish coat. An air blast and a water spray cool the strip on the exit side of the oven. The water is then removed by squeegee rolls and a chevron air dryer. The finished coils are wound on one of two tandem rewind mandrels and cut to required size by a guillotine shear on the exit side of the air dryer.

It is of interest to note that the line has been designed to allow for embossing the painted strip. The embossing stand is situated in the line between the exit air dryer and the exit shear. The embossing rolls are brought into mesh on strip to be embossed and separated when the product is to remain plain. Various standard diamond and stucco embossing patterns are available at present.

Time and temperature in the curing ovens are critical factors influencing product quality, so that the material must move continuously at a uniform rate. The accumulator at the head of the line can collect enough material to give the operator ninety seconds to shear the tail end of the paid-out coil ; shear the front end of the coil to be started from the tandem pay-off ; and to join the strips together. The strips are stitched together by two Bostitch machines, mounted one on each side of the line. Each machine installs a row of stitches halfway across the sheet and then retracts to its starting position clear of the strip edge.

Formation of Diamond by Shock

IN the course of a programme conducted at the Poulter Laboratories, of the Standford Research Institute, Menlo Park, California, to study the effects of explosive shocks on various minerals, samples of spectroscopically pure artificial graphite were exposed to shock pressures estimated at 300,000 atmospheres for one micro-second. The recovered fragments, which microscopically resembled the original material, were rather brittle and did not exhibit the greasy feel of normal graphite when ground in a mortar. When a piece of this material was rubbed between a polished sapphire and a glass slide, fine scratches appeared on both the glass and the sapphire. X-ray diffraction patterns of the "shocked" graphite and of control specimens were made with filtered iron radiation in a 114mm diameter Phillips camera. The pattern of shocked graphite showed three additional lines, weak and slightly broadened, which could be indexed as the (111), (220), and (311) diamond reflections. These are the only possible reflections from diamond with filtered iron radiation. The line positions coincided with a standard pattern of diamond powder recorded in the same camera and the lattice spacing agreed with that reported by Swanson and Fuyat, of the N.B.S.

Some of this shocked graphite was ground in a glass mortar to —325 mesh and centrifuged in bromoform, density 2·87 grammes per cubic centimetre. Since the respective crystal densities of graphite and diamond are 2·25 and 3·5, only particles containing at least 50 per cent diamond by volume could settle. X-ray diffraction, electron diffraction, and microscopic examinations were made of the dense fraction. With filtered copper radiation, all of the permissible diamond lines were observed. However, the lines were so broadened that the K-alpha doublet could not be resolved even for the (331) reflection. Transmission electron diffraction patterns of individual particles were made with a Hitachi model HU-10 apparatus. One of these particles, about one cubic micron in volume, gave a pattern of partial diffraction rings which corresponded to the first ten diamond reflections. Microscopic examination showed the particles to be small, generally ten microns or less in diameter. They looked like meteoritic carbonados.

The most conservative estimates of the temperature and pressure which occurred during the shock are well within the region of diamond stability. However, in the very short time at pressure available in these experiments it is unlikely that a mechanism involving wide-scale atomic movement and growth processes can be responsible for the graphite-diamond transition. A comparison of the structures of graphite and diamond reveals an available diffusionless mechanism for the transition.

The basic element of the graphite structure is a sheet of carbon atoms in which each atom is bonded to three other atoms at 120 deg., forming a hexagonal network. These sheets are stacked in such a manner that alternate atoms in a sheet lie above the centres of the hexagons in the sheet below. There are two simple stacking arrays that meet this condition. In the more common hexagonal form of graphite the stacking is . . ABAB . . In the rhombohedral form (Lipson and Stokes) the stacking is . . ABCABC . . ; i.e., the atoms in the third sheet occupy a position symmetrically related to the first two. It has been pointed out that the arrangement of atoms in diamond differs from rhombohedral graphite only in two respects. In diamond the sheets of hexagons are puckered and they are much closer together, 2·06 Å in diamond, 3·35 Å in graphite. It appears that a simple compression in the stacking (c-axis) direction would suffice to convert rhombohedral graphite to a form very close to diamond. To complete the transition the sheets must become puckered, requiring that each atom move only about 0·25 Å.

In the shockloading experiments a commercial artificial graphite was used. X-ray patterns of this material revealed that it is predominantly hexagonal graphite, but that there is considerable disorder in the structure. Comparison of these patterns with published patterns indicates that this graphite contains about 20 per cent disordered structure. It is probable that some of this observed disorder is due to the presence of small domains of rhombohedral graphite.

Microphotograph of a recovered fragment of artificial diamond made from graphite by explosive shock

It is suggested that the graphite-to-diamond transition observed in these experiments took place in properly oriented domains of rhombohedral graphite in the manner already described. In support of this mechanism is the fact that the experimenters have not yet been able to detect diamond in shock-loaded specimens of pure hexagonal graphite. The formation of diamond in shock-loaded graphite has been observed repeatedly and reproducibly in these Laboratories during the past year and a half. Work is in progress to test the proposed mechanism and to define more accurately the pressure and temperature in the specimens during the shock.

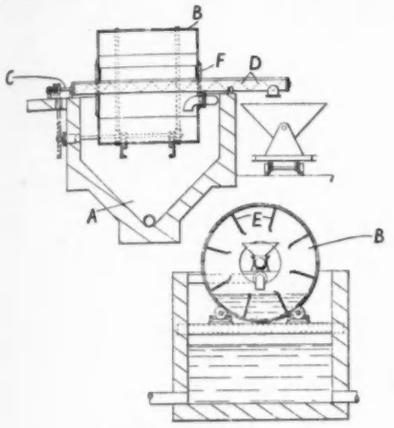
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

SCREENING PLANT

874,594. February 22, 1960.—ROTARY DRUM SCREENS, Hartleys (Stoke-on-Trent), Ltd., Kearsley Chambers, Shelton Old Road, Stoke-on-Trent, Staffordshire. (*Inventor : Cyril John Hartley.*)

This invention relates to rotary drum screens such as are used in the treatment of sewage, trade wastes, river water or other liquid, for the removal of solid or semi-solid matter. With reference to the accompanying drawings, the tank *A* has built-in horizontal



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girders supporting a roller cradle carrying a large perforated cylindrical drum *B*. An electric motor alongside the tank is connected by chains with a conveyor driving shaft *C*, and two rollers which rotate the drum by friction. The screw conveyor *D* runs in a trough which extends lengthwise through the drum. The drum has internal radial vanes *E* with curved tips at their inner edges. The drum has end plates with an opening in each, the opening *F* at the feed end being somewhat smaller than that in the opposite end which serves for an overflow outlet. The flow forms a body of liquid along the lower part of the perforated drum in which, as it is rotated, the vanes continually pick up the solid and semi-solid material and as they pass overhead they deposit the refuse into the conveyor. The screened liquid falls into the tank below. If for any reason an excess of flow should occur, the level of the flow in the drum would rise and pass out through the larger outlet.—*August* 10, 1961.

METALLURGY

874,573. March 9, 1960.—TREATING OF ORES, Gebr. Giulini G.m.b.H., Ludwigshafen-Rhein, Germany. (*Inventors : Egon Cherdron, Hermann Ruter and Fritz Weingartner.*)

The invention is concerned with improvements in or relating to the recovery of titanium or titanium compounds from titanium ores also containing iron. The process yields substantially all the titanium in soluble form, in which the titanium ore is treated with aqueous hydrochloric acid containing at least 32 per cent by weight HCl at a temperature of at least 90 deg. Cent. for not more than two hours, the reactants being vigorously agitated throughout. It is important that a high initial concentration of titanium tetrachloride is attained in the shortest possible time, since highly concentrated solutions of titanium tetrachloride are more resistant to hydrolysis. Thus, for example, it is possible to decompose ilmenite with concentrated hydrochloric acid at 100 deg. Cent. in a closed vessel which is rapidly tumbled, so quickly that even after ten minutes a degree of decomposition of about 95 per cent is attained, and virtually all the titanium is present in the dissolved state. To achieve rapid reaction it is important to agitate the reactants very thoroughly. With slower decomposition on the other hand it has been found that a proportion of the decomposed titanium dioxide is present in solid form. Some substances possess the property of causing additional reduction or prevention of undesired hydrolysis during the decomposition. Examples of substances which effectively inhibit hydrolysis are phosphorus compounds, such as phosphorus pentoxide, phosphoric acid or salts thereof. Thus, for example, the decomposition with hydrochloric acid can be carried out in the presence of 2·5g of phosphorus pentoxide per litre of decomposition solution at a temperature of up to 140 deg. Cent., without hydrolytic decomposition of titanium tetrachloride, while in the absence of phosphorus pentoxide or phosphoric acid or salts thereof the working temperature should preferably not exceed 100 deg. Cent. After separation of the titanium and iron from the solution, the hydrochloric acid solution may be recycled and used again. The iron can be separated by precipitating ferrous chloride which may be thermally decomposed to give hydrochloric acid gas, which may be recycled by absorption into the aqueous hydrochloric acid solution. In order that the invention may be well understood examples are given by way of illustration.—*August* 10, 1961.

874,366. July 20, 1959.—TREATMENT OF STEEL SURFACES, British Iron and Steel Research Association, 11, Park Lane, London, W.1. (*Inventor : Frederick William Salt.*)

This invention is concerned with improvements in or relating to the electroplating of a ferrous surface with another metal and is particularly concerned with the production of tinplate. It was found that the porosity of an electro-deposited metal coating on a ferrous surface, more particularly a mild steel surface, could be reduced by electro-smoothing the metal to be plated prior to electroplating. By electro-smoothing any high points of the metal surface are removed ; if these high points are not removed they tend to receive a disproportionate amount of deposit at the expense of the surrounding areas. More particularly the invention provides a process for the production of tinplates in which the steel is electro-smoothed in an aqueous bath having a pH of 4·0 to 6·0 and containing acceptor ions with a low diffusion coefficient in order to obtain low limiting current densities for anodic dissolution. It is preferred to effect the electro-smoothing with a new type of bath in which low limiting current densities for anodic dissolution are obtained by using acceptor ions with a low diffusion coefficient, such as the anions of organic hydroxy carboxylic acids. In order to achieve the maximum rate of smoothing, the bath is preferably operated on the rising portion of the anode potential/current graph just below the horizontal portion corresponding to the limiting current density for anodic dissolution.

The composition of such an electro-smoothing bath in which the citrate anion is employed as the acceptor ion is, for example, as follows :

	Grammes per litre
Sodium citrate (+2 mols. H_2O) ...	49–147
Citric acid	2– 50
Sodium chloride...	5– 20

The proportions of sodium cirtrate and citric acid within these ranges should be such that the pH of the bath is from 4·0 to 6·0. In order to obtain the maximum rate of smoothing, it is preferred to operate a bath having the above composition with an anode current density of from 50 to 150 amps per square foot for from 0·2 to 15 seconds with the bath at a temperature of from 5 deg. to 35 deg. Cent.—*August* 2, 1961.

INTERNAL COMBUSTION ENGINES

874,756. September 25, 1958.—FUEL FOR DIESEL ENGINES, Esso Research and Engineering Company, Elizabeth, New Jersey, United States of America.

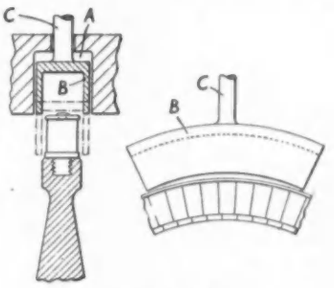
It has been found that acceptable diesel fuel compositions can be prepared by blending certain gasoline hydrocarbons of low octane number with certain polynuclear aromatic hydrocarbons and non-benzenoid, hydrocarbon-soluble, hydroxylated hydrocarbons, the latter having at least six carbon atoms in the molecule and boiling below 750 deg. Fah.

This invention provides a fuel for compression ignition engines comprising a mixture of from 30 to 55 weight per cent of low octane petroleum gasoline hydrocarbons, boiling in the range of 150 deg. to 450 deg. Fah.; from 25 to 40 weight per cent of polynuclear aromatic hydrocarbons, boiling in the range of 450 deg. to 750 deg. Fah., and preferably having from 2 to 4 aromatic rings per molecule; and from 15 to 30 weight per cent of a non-benzenoid, hydrocarbon-soluble hydroxylated hydrocarbon, having at least six carbon atoms and boiling below 750 deg. Fah. The volatile petroleum hydrocarbon components of low octane number usually have an octane number of 50 or lower, and such components have not previously been incorporated in diesel fuels. A particularly preferred composition in accordance with the present invention consists of from 20 to 25 weight per cent normal heptane; about 20 weight per cent low octane naphtha boiling in the range 155 deg. to 325 deg. Fah.; about 25 weight per cent *n*-decanol; and from 35 to 30 weight per cent of polynuclear aromatic hydrocarbons having from 2 to 4 cyclic rings in the molecule and boiling in the range of 550 deg. to 700 deg. Fah. The fuel compositions of the invention will in general have a viscosity of at least 1·2 centistokes at 100 deg. Fah., preferably from upwards of 1·4, e.g., 1·4 to 3, centistokes at 100 deg. Fah. to avoid the danger of excessive fuel pump wear and to allow the injection pump to meter the fuel accurately. The compositions are good lubricants for the fuel pump, they have a high specific gravity and good cold starting properties. Furthermore, they have a low freezing or separation point, or cloud or pour point ; usually this value is below 0 deg. Fah.—*August* 10, 1961.

TURBINES

874,835. December 16, 1959.—TURBINES, Power Jets (Research and Development), Ltd., 25, Green Street, London, W.1. (*Inventor : Neil Milligan Clark.*)

The invention relates to a turbine which may be subjected to periods of rotation reverse to its normal, such as in a marine turbine installation which comprises two coupled turbines, one for ahead and the other for astern propulsion. Either of these turbines may be driven while the other is rotated in a reverse direction. Such rotation will induce a flow over the blading of the turbine concerned and give rise to windage losses which absorb power from the working turbine. The invention provides a rotor arrangement having a divided shroud to mask the working surfaces of the blades during reverse rotation. Some embodiments of the invention are described by way of example only with reference to diagrammatic drawings. A part of the turbine casing has a recess *A* for receiving a shroud *B* of channel cross-section with an operating rod *C*. Further parts complete the shroud circumferentially, each part being provided with an operating rod. When the rotor is



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rotated in a direction reverse to that when being driven the shroud is moved inwards to surround the blading as shown in broken lines. In this position the ends of the shroud parts are adjacent to one another and the completed shroud has the effect of substantially enclosing the blading with very little clearance which may be of the order of $\frac{1}{4}$in or less. The shroud is retracted into the recess when turbine blading is driven.—*August* 10, 1961.

TOOLS

873,529. August 12, 1958.—CAST HIGH-SPEED STEEL TOOLS, Gebr. Bohler and Co. Aktiengesellschaft, Elisabethstrasse 14, Vienna 1, Austria. (*Inventor : Karl August Krekeler.*)

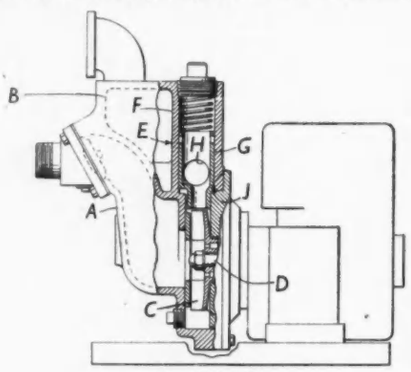
By subjecting cast high-speed steel tools to an annealing treatment as described in the invention it is stated to make possible work capacities at least as high as those with tools made from hot-worked steels of the same type. Annealing treatment in accordance with the invention can be applied to all previously known high-speed steel alloys and leads to increases in work capacity in many cases, but more particularly in the case of cobalt-alloyed high-speed steels. For instance, the precision casting process was used to make tools from a high-speed steel alloy with 1·65 per cent C, 12·5 per cent W, 4 per cent Cr, 4 per cent V and 5 per cent Co, the remainder being iron and unavoidable impurities. These cast tools were annealed for one hour at 1100 deg. Cent. then cooled in air and finally hardened in the usual manner ; the tools were first pre-heated

to 850 deg. Cent. then raised to a temperature between 1230 deg. and 1260 deg. Cent. in a salt bath and hardened by quenching in oil and finally tempered twice, for one hour in each case at 570 deg. Cent. No overheating phenomena were observed. The tools were tested in a milling operation and had an average cutting distance of 2400m. A number of comparisons between the annealed cast high-speed tools, forged tools and unannealed tools are given in the specification.—*July* 26, 1961.

PUMPS

873,968. November 2, 1959.—SELF-PRIMING CENTRIFUGAL PUMPS, Worthington Corporation, 401, Worthington Avenue, Harrison, State of New Jersey, U.S.A. (*Inventors: Walter Kurt Jekat, John Henry Doolin, and Theodore Robert Esatow.*)

This invention relates generally to a self-priming centrifugal pump adapted to be operated at different capacities or heads by pre-selecting an impeller of a particular diameter according to the capacity or head required. More particularly, this invention contemplates providing this pump with means for retaining the self-priming feature regardless of the diameter size of the impeller selected. A tube, readily mounted in the pump casing, is pre-selected to co-act with a particular impeller so that the operative relation between the tube and the impeller will provide rapid self-priming characteristics. The drawing shows a self-priming centrifugal pump, which includes a casing having a suction chamber *A*, a discharge chamber *B* and an impeller chamber or volute *C*. The impeller chamber is adapted to receive one end of a shaft *D* which extends through a packing gland and has the impeller mounted on the end. To provide for the retention of the prime during pump operation the pump casing has a means, generally designated *E*, associated with the impeller whereby the self-priming characteristic is retained without regard to the diameter size of the impeller. This means comprises a recirculation chamber or guide *F* formed in the casing in spaced relation with the impeller chamber and includes a passage for fluid flow between the discharge chamber and the impeller chamber. Slidably disposed in the recirculation



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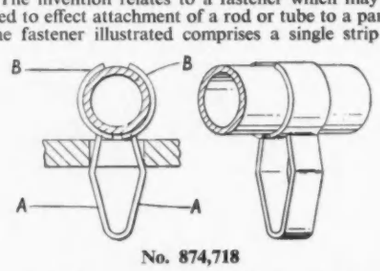
chamber is a recirculation tube *G* with a flow passage *H* which coincides with the passage in the recirculation chamber to provide for return flow of fluid from the discharge chamber to the impeller chamber. In order to limit the entry of the recirculation tube into the impeller chamber and to maintain its leading and trailing edges in close clearance with the impeller the tube has a stop shoulder which sits on a shoulder *J* on the recirculation chamber. To hold the tube *G* in operative relation with the impeller during pumping a spring is fitted in the recirculation chamber and held by a plug in the casing as shown.—*August* 2, 1961.

FASTENINGS

874,718. April 11, 1960.—FASTENER, F. T. Products, Ltd., 200, Gresham House, Old Broad Street, London, E.C.2. (*Inventor: Eric Birger Fernberg.*)

The invention relates to a fastener which may be used to effect attachment of a rod or tube to a panel. The fastener illustrated comprises a single strip of



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spring metal bent roughly "U"-shape. The web of the "U" provides a closed nose from which extend two limbs *A*. Curved feet *B* at the two ends of the limbs form part of a cylinder of equal or similar diameter to that of the tube to be fixed. To assemble the tube to the panel, the tube is first set between the feet and the fastener is then sprung, nose first, into the hole in the panel as shown. The elbows formed in the limbs project below the hole to resist withdrawal of the fastener from the panel. The tube cannot be removed from the fastener by manipulation from the upper side of the panel but only by squeezing together the limbs from the underside of the panel. The strength of each fastener is preferably such that this can be done only with a pliers or other suitable tool.—*August* 10, 1961.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

INTERNAL COMBUSTION ENGINES (SPARK IGNITION TYPE)

No. 765 : 1961. Price 6s. When this specification was first published in 1938 it was entitled *Internal Combustion Engines, Carburettor Type.* The carburetter is now sometimes replaced by fuel injection—spark ignition being retained; and the title and scope of the standard have accordingly been changed. Instead of basing engine rating on a twelve-hour running period, the revised standard introduces the basis of continuous running (limited only by overhaul requirements) and as it is intended to cover engines with a wide range of duties, three intermittent ratings are included. The single class of governing specified in 1938 is now replaced by two classes.

A new appendix enables the results of tests made at high altitudes, temperatures and humidities to be correlated with standard conditions. Another appendix relates the standard operating conditions and ratings specified in B.S. 765 with those operative in the United States, Germany and the U.S.S.R.

BOLTING FOR THE PETROLEUM INDUSTRY

No. 1750 : 1961. Price 10s. This revision of B.S.1750 has been prepared to take account of several developments which have occurred since the standard was first published in 1951. One of the most important of these was the revision of B.S.1506, "Steels for use in the chemical, petroleum and allied industries," with which B.S.1750 is closely associated. The requirements for material in the latter standard are now in accordance with the provisions of the current B.S.1506 and a completely new section covering alloy steel stud-bolts and nuts for low temperature service has been added. As in the case of the earlier edition of B.S.1750, however, the international character of the petroleum industry has been kept very much in mind and every care has been taken to ensure that interchangeability between equipment produced by British and American manufacturers is maintained. The standard accordingly provides for four grades of bolting which are equivalent in service to the corresponding grades in the appropriate specifications issued by the American Society for Testing Materials and includes provisions for marking which are the same as those for the comparable American bolting and are derived from A.S.T.M. data. Although the standard now refers only to bolting with Unified threads, it no longer includes dimensions of carbon steel bolts, screws, studs and nuts for moderate duty service, but refers direct to B.S.1769, "Unified black hexagon bolts, screws and nuts. (UNC and UNF threads)—heavy series," and to B.S.2693, Part 1, "General purpose studs," except for such properties as are not included in those standards.

DETERMINATION OF AIR POLLUTION PART 1 : SPECIFICATIONS FOR DEPOSIT GAUGES

No. 1747 : 1961. Price 5s. When B.S.1747 was first published in 1951 it was concerned solely with deposit gauges. Now it is being re-issued in several parts to cover, in addition, apparatus and procedure for the measurement of (1) fine particles (smoke), and (2) gaseous impurities, as well as the solid material (such as grit) which is measured by the deposit gauges specified in Part 1 of the standard.

CLASSIFICATION AND METHODS OF SAMPLING AND TESTING OF INSULATING REFRACTORY BRICKS

No. 2973 : 1961. Price 6s. The first consideration in selecting the most appropriate insulating refractory for any application must be the limiting service temperature.

The system of classification specified in the standard is based on the behaviour of the refractory material in the permanent linear change test conducted at a specified temperature. The method of determining the permanent linear change is given. A page is included on sampling and there are described methods of determining dimensions, warpage (which includes convexity and concavity), bulk density, cold crushing strength, modulus of rupture, and thermal conductivity.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Sept. 11.—BOLTON BRANCH: Railway Hotel, Trinity Street, Bolton, "Automatic Control Equipment for Small and Medium Oil-Burners," L. G. Barnfield, 7.45 p.m. ★ CENTRAL LONDON BRANCH: White Hall Hotel, Bloomsbury Square, London, W.C.1, "History and Working of the Stock Exchange," C. H. Dreyfus, 7.15 p.m.

Tues., Sept. 12.—ALDERSHOT AND DISTRICTS BRANCH: Queens Hotel, Farnborough, Hants, "Swedish Supply and Hot-line Working," A. Flude, 8 p.m. ★ CHESTER AND DISTRICT BRANCH: Blossoms Hotel, Chester, Ladies' Meeting, 7.45 p.m. ★ GLOUCESTER AND DISTRICT CENTRE: Royal Hotel, Station Road, Gloucester, "The Panelec Warming System," 8 p.m. ★ LEICESTER BRANCH: Westcotes Constitutional Club, 124, Wilberforce Road, Leicester, Chairman's Address, 7.30 p.m.

Wed., Sept. 13.—BIRMINGHAM BRANCH: Engineering and Building Centre, Stephenson Place, Birmingham, 2, "Diesel-electric Propulsion for Trains," J. L. Aspland, 7.30 p.m. ★ EAST ANGLIA (THETFORD) CENTRE: Red Lion Hotel, Thetford, Norfolk, "The Protection of Electrical Installations," J. A. Robbins, 7.30 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH: Royal Air Force Association Club, Cosham, Portsmouth, Films, 7.30 p.m. ★ WOLVERHAMPTON AND DISTRICT BRANCH: Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, Staffs, "Static Switching Control Systems," B. A. W. Midgley, 7.45 p.m.

Thurs., Sept. 14.—BRADFORD AND DISTRICT BRANCH: The Midland Hotel, Bradford, "Lighting in Home and Industry," J. W. Howell, 7.30 p.m. ★ BRIGHTON, HOVE AND DISTRICT BRANCH: The Cricketers Hotel, Black Lion Street, Brighton, 1, "Modern Trends in Coil Winding Wire," C. P. Fox, 7.30 p.m. ★ SOUTH WEST LONDON BRANCH: Prince of Wales Hotel, London, S.W.19, "Unearthing London," Norman Cook, 8 p.m. ★ NOTTINGHAM BRANCH: People's College of Further Education, Castle Road, Nottingham, Chairman's Address, 7.30 p.m.

Fri., Sept. 15.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, "Electronic Controls and Photo-electric Equipment," G. I. G. Ive, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Sept. 26.—SOUTHERN SECTION: Technical College, Farnborough, Chairman's Address, "Lighting—Facts and Fancies," W. A. Gambling, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Thurs., Sept. 21.—WEST MIDLANDS SECTION: College of Further Education, Green Close Lane, Loughborough, "Diesel Electric Installation for Propulsion and Cargo Handling of the Bulk Cement Carrier 'John Wilson'," H. E. Muckley and J. G. Derrington, 6 p.m.

Tues., Sept. 26.—SOUTHERN JOINT BRANCH: Royal Beach Hotel, South Parade, Southsea, Joint meeting with the Royal Institution of Naval Architects, "High Speed Craft," Cdr. P. Du Cane, 7.30 p.m.

INSTITUTE OF NAVIGATION

Tues., Sept. 26.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, All-day meeting, "The Transit Navigation Satellite System," 10 a.m.

INSTITUTE OF PETROLEUM

Wed., Sept., 20.—61, New Cavendish Street, London, W.1, "Airborne Techniques in Petroleum Exploration," W. Domzalski, 5.30 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Thurs. and Fri., Sept. 21 *and* 22.—Department of Physics, University College of North Wales, Bangor, Joint conference on "Radiospectroscopy of Solids," Guthrie Lecture to be delivered during the conference—"The de Haas-van Alphen Effect and the Electronic Structure of Metals," D. Shoenberg.

Thurs. and Fri., Sept. 28 *and* 29.—ELECTRONICS GROUP: Assembly Room, Town Hall, Leamington Spa, Joint conference on "The Physics of Gas Discharge Devices."

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Sept. 8.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, Conference on "Microwave Measurement Techniques."

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Sept. 26.—Lecture Hall, Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Ordinary General Meeting, Presidential Address, J. F. Harrison, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Thurs., Sept. 14.—LUBRICATION AND WEAR GROUP (EASTERN BRANCH AREA): Social Club, Hoffmann Manufacturing Company, Ltd., Chelmsford, "Lubricants in Nuclear Reactors," P. E. B. Vaile, 7.30 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Sept. 12.—EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, Members' Evening, 7.30 p.m.

Wed., Sept. 13.—WESTERN BRANCH: Royal Clarence Hotel, Exeter, Film, "The Hinkley Point Power Station," 7 p.m.

Thurs., Sept. 14.—NORTH EAST BRANCH: Roadway House, Oxford Street, Newcastle-upon-Tyne, 1, "Insurance and the Plant Engineer," J. H. Oswald, 7 p.m. ★ GLASGOW BRANCH: Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, "Electronic Control of Machine Tools and Production Plant," 7.15 p.m.

Wed., Sept. 20.—KENT BRANCH: South Eastern Gas Board Lecture Hall, 95, High Street, Rochester, "Timber—Its Uses and Characteristics in Plant Engineering," R. P. Woods, 7 p.m.

Thurs., Sept. 21.—BLACKBURN BRANCH: Castle Hotel, Blackburn, "Shell Boiler Developments," A. D. C. Gunn, 7.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Mon. to Thurs., Sept. 11 *to* 14.—Lecture Theatre, 4, Hamilton Place, London, W.1, Eighth Anglo-American Aeronautical Conference, 9 a.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Wed., Sept. 13.—EAST MIDLANDS BRANCH: College of Technology, Ashby Road, Loughborough, One-day conference on "The Application of Instrumentation in Industry with Special Reference to the Problems of the Small Firm," 9.30 a.m.

Tues., Sept. 26.—Manson House, 26, Portland Place, London, W.1, "Underground Gasification of Coal—Some Features of Instrumentation," A. E. Balfour, and "Trends in Mining Instrumentation," A. E. Bennett, 6.30 p.m.